GOVERNANCE AND MANAGEMENT OF THE UPPER ACRE RIVER IN PANDO, BOLIVIA

By

GABRIELA STOCKS

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

UNIVERSITY OF FLORIDA

2007

In memory of Stephenie

ACKNOWLEDGMENTS

This work would not have been possible without the guidance and support of Dr. Anthony Oliver-Smith, whose patience throughout this process has been phenomenal. I would also like to thank my committee members, Dr. Marianne Schmink and Dr. James Jawitz for their helpful input. Dr. Peter Cronkleton of the Center for International Forestry Research (CIFOR) in Santa Cruz, Bolivia was a key player in the selection of the research communities and in helping me establish contacts in Pando. Without him and CIFOR staff member Rolando Haches, I would have been lost. The staff of the Fundación Jose Manuel Pando and the Centro de Investigación y Preservación de la Amazonía at the Universidad Amazónica de Pando were also incredibly helpful during my time in Cobija.

I would also like to thank NSF-IGERT Working Forests in the Tropics program at the University of Florida for funding my research.

The love and support offered by both my academic and non-academic communities have sustained me throughout this process. Thanks go to my parents, Kathleen and Tony, and friends Elizabeth, Heather, and Kelly for being there at the beginning of my journey; to Isadora, Yael, and Ava for being there in the middle; and to Lin, Kelly, Alfredo, and Franklin for being there at the end. Most importantly, love and thanks go to Forrest, for being there always.

Last but not least, my great appreciation goes to the community members of San Pedro and San Miguel for tolerating a stranger in their midst. Their willingness to participate in my research went beyond the call of duty.

TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEL	Anguila electrica
AGU	Agua
ALO	Alontra
ANG	Anguila
ANT	Anta
ARB	Arboles
ARR	Arroyos
ASA	Asaí
BAC	Bacu
BAG	Bagre
BOA	Boa
BOC	Boca chica
BOD	Bodon
CAC	Cachimbu
CAI	Cairara (mono blanco)
CAN	Sause (caña)
CAO	Cacao
CAP	Capibara
CAR	Caparari
CAS	Castaña
CED	Cedro
CEM	Cedro macho
CHA	Chancho
CHM	Chancho del monte

CHT	Chancho de tropa
CHU	Chuchio (caña brava)
CIC	Cicurí
COB	Cobra
COP	Copaiba
CUY	Cuyu
DEN	Dentudo
DOR	Dorado
GAR	Garza
JAC	Jacaré
JCL	Jochi colorado
JOC	Jochi
JOP	Jochi pintado (agouti)
JUB	Jacareuba
JUN	Jundia
LIM	Limon
LON	Lontra
LOR	Loro
MAD	Madera
MAJ	Majo
MAN	Mandarina
MAP	Mapajo
MAR	Mara
MAS	Masaranduba
MAT	Matrinchon

MDN	Mandin
MGO	Mango
MMN	Mono maneche
MON	Mono
NAR	Naranja
PAC	Pacu
PAJ	Pajaro
PAL	Palometa
PAP	Papaya
PAT	Pato
PAV	Pava
PCY	Pacay
PDO	Pescado
PDP	Pico de pato
PER	Perdiz
PES	Pescado perro
PET	Peta
PIC	Pichico (chichilo)
PIR	Piranambu
PLA	Platano
PLT	Plantas
PNA	Piraña
RAY	Raya
SAB	Sabalo
SAP	Sapo

SAR	Sardina
SDA	Sandia
SDG	Sangre de grado
SIL	Mono silvador
SOC	Socó
SUR	Surubi
TAT	Tatu
TIG	Tigre
TOC	Toco blanco
UDG	Uña de gato
VEN	Venado
VIB	Vibora
VTN	Venton

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Arts

GOVERNANCE AND MANGEMENT OF THE UPPER ACRE RIVER IN PANDO, BOLIVIA

By

Gabriela Stocks

August 2007

Chair: Anthony Oliver-Smith
Major: Anthropology

Tropical rivers in rural areas are likely to have good water quality, but current trends indicate that increasing development pressures could have a deleterious effect on these water systems. One potential strategy for counteracting these negative impacts is the devolution of watershed management into the hands of local users. However, it cannot simply be assumed that local communities naturally make effective resource managers. A careful examination of the presence or absence of social and institutional characteristics necessary for effective resource management must be carried out.

The research presented in my thesis attempts to address this issue at a small scale by focusing on two neighboring Bolivian communities located on the Upper Acre River in the department of Pando. The objective of my research was to determine how these two culturally distinct communities utilize and manage river resources, including riparian areas, and to evaluate whether features favorable to collective action for the protection of these resources exist.

Field work was conducted over a 12-week period. Principle methodologies employed included participant observation, semi-structured interviews, and participatory mapping. These methodologies were supplemented by the use of freelisting and Global Positioning System data.

The results of my research indicate that neither community makes as extensive use of river resources as might be expected of Amazonian river-dwellers. Water quality in the Acre River was perceived to be poor by most households, and concern was expressed about the health impacts associated with coming into contact with river water. Households were generally conscientious about maintaining riparian buffers when creating agricultural fields near water bodies and expressed a clear understanding of the value of riparian areas. This individual consciousness had not coalesced into formal management rules in either community or between neighboring communities, however, and is unlikely to do so in the future without motivation by outside actors.

CHAPTER 1
INTRODUCTION

Statement of the Problem

Tropical rivers in rural areas are likely to have good water quality (Goulding et al. 2003), but current trends indicate that increasing development pressures could have a deleterious effect on these water systems. One potential strategy for counteracting these negative impacts is the devolution of watershed management into the hands of local users.

In the Amazon basin, local populations are often dependent upon resources provided by rivers and streams, and water quality is of critical importance. With an average rainfall ranging from 5000 mm/year in parts of the western Amazon to 2000 mm/year in eastern Brazil, there is ample water to support human populations. The abundance of fresh water in this region has resulted in a lifestyle among many indigenous and colonist communities that is strongly linked to surface water for consumption, recreation, transportation, agriculture in riparian buffer zones, and access to food sources such as fish and aquatic plants (McClain et al. 2001).

Protecting the water quality necessary to support these uses can be challenging, especially in countries of the western Amazon like Peru and Bolivia. First, a severe shortage of state financial resources limits water infrastructure development such as sewage and drinking water treatment systems. Available financial resources are often used in more populated regions and where water shortages are most likely to occur, such as in the higher elevations of Peru (McClain et al. 2001). Second, the remoteness of much of the Amazon basin prohibits such infrastructure development even if money were available. Finally, though many countries in the Amazon basin have developed seemingly strong water policies, they often only apply to upland, water-scarce regions. Even when policies do apply to lowland areas, they are rarely enforced (McClain 1999).

Given this combination of factors, the task of developing watershed management strategies that protect water quality will most likely be left to local people.

McClain (1999) makes a convincing argument for proactively placing water resource management in the Amazon basin into the hands of local people. In light of the problems discussed above, intelligent use of natural features, including maintenance of riparian buffer zones, wetlands and floodplains, could be the best option for watershed protection. Local communities would seem to be the natural (and best) choice for resource managers because they are dependent upon good water quality, are the end users of the resource, and have the capacity to protect water quality at its source. On the other hand, there are also many cases in which local management has not resulted in the protection of the resources in question, so it cannot simply be assumed that local communities will naturally make good resource managers. Each situation must be viewed independently through a careful examination of the presence or absence of the social and institutional characteristics necessary for effective resource management.

Theoretical Framework: Common Property Resources and Collective Action

A popular framework for analyzing resource management is common property theory. Since Garrett Hardin's pessimistic prediction in 1968 that all common property is doomed to overuse and eventual destruction, theories on this subject have abounded. Over time, a distinction has been made between open-access resources and common-pool resources. Generally speaking, open-access resources are those to which anyone has access, whereas "common-pool regimes" (McKean 2000) are those in which a group of people share rights to the resource, the ability to exclude other users, and obligations to each other (Hall 1997; McKean 2000).

Shared access to a resource can suggest a need for collective action to manage that resource. Collective action for resource protection depends on two structural features:

1) members' livelihoods must depend on access to a clearly defined stock of natural resources and 2) long-term protection will depend on group solidarity (Hall 1997; Petrzelka and Bell 2000). The first of these features reflects the idea that people need to see a benefit to themselves or to their community in order to act (Hall 1997). The second feature reflects the idea that participants need assurance that there will be equal effort and reciprocity from other participants in the common property resource (CPR) system (White and Runge 1994) *and* that features of social organization outside the CPR system contribute to its successful implementation (Petrzelka and Bell 2000; Trawick 2001). Ostrom (1990) has also outlined the principles that make common property resource systems successful: an ownership arrangement with management rules, clearly defined physical boundaries, sanctions to ensure compliance and conflict-resolution mechanisms.

Water resources are somewhat unique with regard to systems of governance. Because they come in a variety of forms (i.e., rivers, lakes, oceans, aquifers), there are also a number of ways in which they can be managed, ranging from open access to common property regimes. Biophysical scale is important in this context in that some water bodies, such as oceans, are extremely difficult to manage collectively (Guest 2003), while others, such as lakes, are more straightforward because they are geographically bounded. Rivers and watersheds can fall into either of these categories, depending on their size and extent. While the body of literature that discusses the communal management of water resources at the small scale (i.e. irrigation systems) is large (see Hunt 1992; Kelly 1983; Kolavalli and Brewer 1999; Mitchell and Guillet 1994; Ostrom and Gardner 1993; Trawick 2001), some studies have also addressed the ways in which groups communally manage water resources at the watershed scale (Lansing 1991; Saravanan 2002; Steelman and Carmin 1998; White and Runge 1994). Most of these cases have

focused on small watersheds in which there is a limited group of relatively homogeneous users. One exception is Bardhan and Dayton-Johnson's (2002) comparative study of large-scale irrigation systems, in which they discuss the negative effects of income, wealth and ethnic/social heterogeneity on cooperation around common property resources. Furthermore, they argue, the upstream/downstream relationship of river users, particularly in larger systems, exacerbates issues of "locational heterogeneity" (Bardhan and Dayton-Johnson 2002:103). In other words, differential opportunities may be available to users at different locations in the watershed, thus affecting their cooperative behavior.

Given the constraints imposed by landscape features and socio-political processes at various scales, questions arise regarding how local watershed management should be coordinated. A starting point could be to determine whether watershed management in specific areas of the tropics can be conceptualized and implemented through a common-pool resources regime. Is river resource use currently regulated by a common property resource system, reflecting the features discussed by Ostrom (1990)? Is there a great enough dependence upon river resources to stimulate protective action (Hall 1997)? Is there a great enough shared identity among the residents of large watersheds to support the collective action necessary to manage water resources effectively (White and Runge 1994)? Do existing forms of social organization support and reinforce common property management (Petrzelka and Bell 2000; Trawick 2001)? My research addresses these questions at a small scale by focusing on water resource use and management in two neighboring Bolivian communities located on the Upper Acre River in the department of Pando.

Research Objectives

The overall objective of my research was to determine how two culturally distinct Bolivian communities in the Acre River basin utilize and manage river resources, including riparian areas,

and to evaluate whether features favorable to collective action for the protection of these resources exist. Specific objectives were fivefold (Figure 1-1). First, my research investigated how indigenous and colonist communities are currently utilizing river resources. Second, I documented any existing strategies for protecting water quality or the abundance of aquatic and riparian resources. Third, I investigated local opinions of water quality and of potential conservation techniques. Fourth, I determined whether communities in this area viewed the river and riparian areas as open-access resources or as common-pool resources. Finally, I analyzed forms of social organization in the area that support or do not support common property resource management.

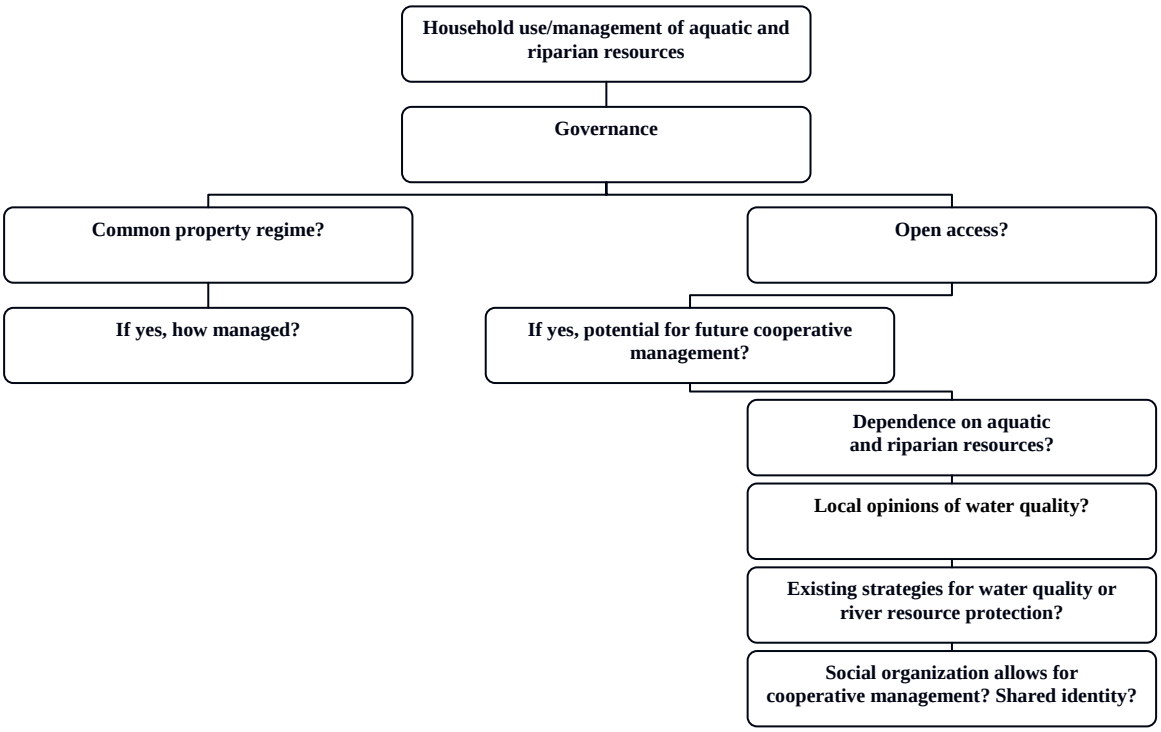

Figure 1-1. A flowchart illustrating the organization of my research questions.

Based on my research objectives, a series of hypotheses emerged. It was expected that the indigenous community would utilize river resources to a greater extent than the colonist community (McClain et al. 2001). Due to the large size of the watershed and the diversity of

communities within it, it was expected that the river would be treated as an open-access resource rather than a common-pool resource. It was expected that the more reliant people were upon river resources for their livelihoods (i.e., the larger the percentage of subsistence products acquired from the immediate area), the greater would be their concern and willingness to participate in cooperative watershed management. Finally, it was expected that forms of social organization in the indigenous community would better support current or future CPR regimes than forms of social organization in the colonist community.

Research Site

Site Selection

The location for my research was chosen because the Bolivian department of Pando is part of a tri-national region known as MAP, also composed of the Peruvian department of Madre de Dios and the Brazilian state of Acre (Figure 1-2). The MAP region has been the subject of discussions of tri-national resource management for a number of years, stimulated by the impending paving of the Transoceanic Highway, which connects the Brazilian Amazon with Peru's Pacific seaports. The Acre River runs through the middle of this region, making it an interesting case for studying the relationship of diverse Amazonian communities to water resources.

The Acre River watershed forms the border between Acre, Madre de Dios and Pando. The river originates in northwest Acre, flows south into Peru, then east into Bolivia, finally turning northeast into Brazil, where it continues through Acre's capital city, Rio Branco (Figure 1-3). It eventually becomes the largest tributary of the Purus River, which itself is a major tributary to the Amazon River. The Acre is considered a white water river, which in the Amazon stands in contrast to black water rivers that tend to be a dark tea color, stained by tannins from organic matter. During the dry season, the Acre's color is usually a dark brown-green. During times of

rain, however, the river becomes laden with silt, a natural condition that is exacerbated by deforestation in the region. Local reports indicate that the river channel is being filled in by this sediment.

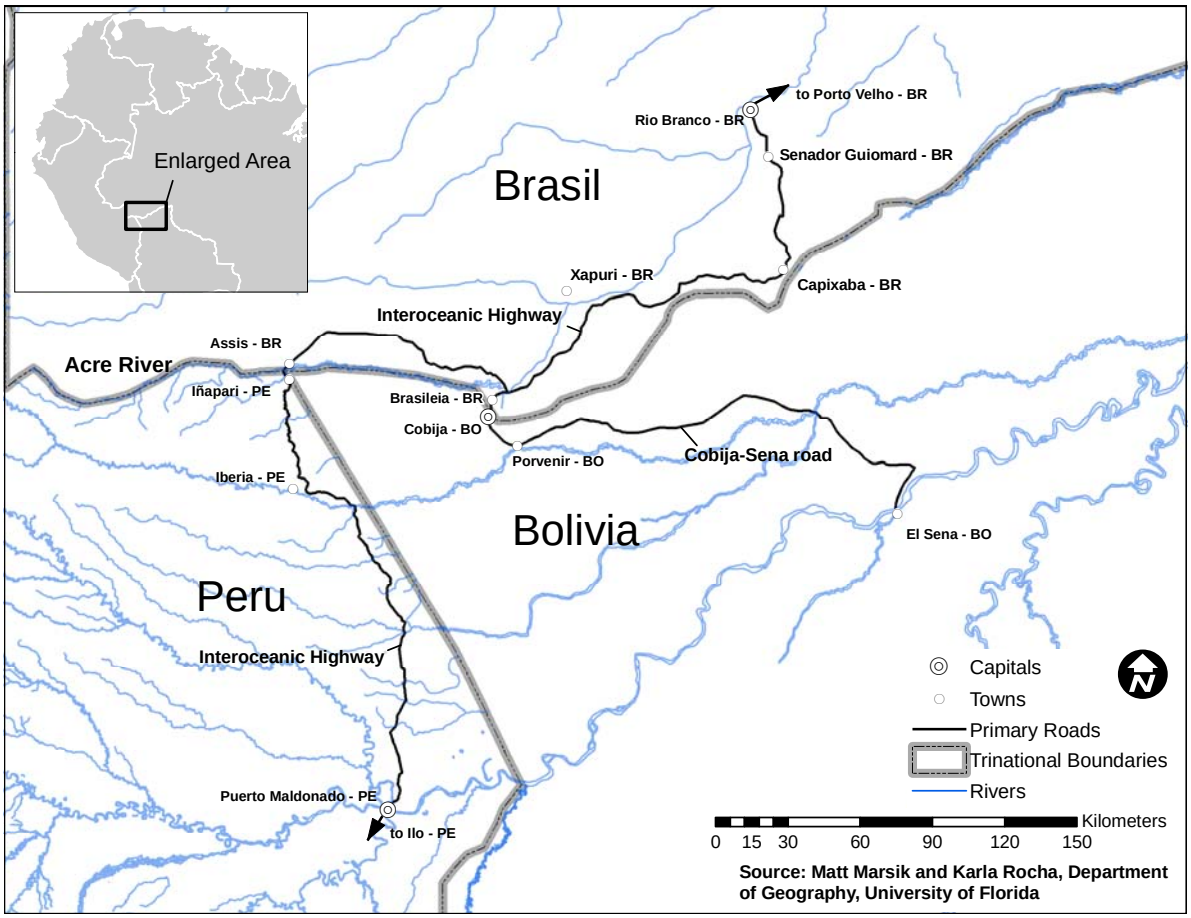

Figure 1-2. The MAP region.

Terrestrially, most of Pando is considered lowland tropical forest. Much of it lies less than 500 meters above sea level and receives approximately 1950 mm of rainfall per year (U.S. Army Corps of Engineers 2004). Due to its relative isolation and lack of infrastructure, Pando has not experienced the level of deforestation that has occurred elsewhere in lowland Bolivia (Pacheco 2002). In recent decades, however, the Bolivian government has attempted to integrate the Amazon region into the national context through forestry programs and land-grants to agriculturalists. Currently, the conversion of forests to agricultural use is the principal cause of

deforestation (Pacheco 2002). This trend will likely continue as the process of integration proceeds.

I chose to work in Pando for three reasons. First, of the three countries that form the Acre River basin, Bolivia contains the shortest stretch of river. This made it possible to more easily access field sites by boat. The confined area also allowed me to experience the social interactions that occur between neighboring Bolivian communities that are under similar socio-political constraints. Second, the tri-national border area is essentially the first major population center in the Acre River watershed (Figure 1-3). This meant that the impacts of upstream activities were easily identifiable and relatively minor. Finally, the Yaminahua-Machineri indigenous territory (legally termed a *Tierra Comunitaria de Origen* (TCO) in Bolivia) is located on the Bolivian stretch of the Acre River. I realized that this would provide an opportunity to compare aquatic resource management practices in two ethnically and socially distinct communities, as my other research site was a community composed of settlers from the Bolivian highlands. This comparison would also reveal whether upstream/downstream arrangements exist between communities in this part of the watershed, particularly among those of different ethnic backgrounds.

Upon my arrival in Cobija, the capital city of Pando, I met the staff of the Fundación Jose Manuel Pando and the Center for International Forestry Research's (CIFOR) local staff member, Rolando Haches. Haches proved to be a critical player in my research, as it was through him that I met Don Manuel Rodriguez, the leader of the Yaminahua-Machineri TCO and an important representative at the Indigenous Center for the Original Villages of Amazonian Pando (CIPOAP). After hearing about my intended research plan, Rodriguez granted me permission to work in the TCO. Haches also introduced me to the mayor of the municipality of Bolpebra, in

which both of my research sites were located. The mayor is also a resident of the community of San Pedro de Bolpebra and was therefore able to give me preliminary authorization to work in his community. After receiving permission to work in each community, Haches and I visited San Pedro during their Mother's Day celebration. I gave a short presentation to those present at the celebration, answered any questions, and introduced myself personally to each person there.[1] I returned to San Pedro two days later to begin data collection.

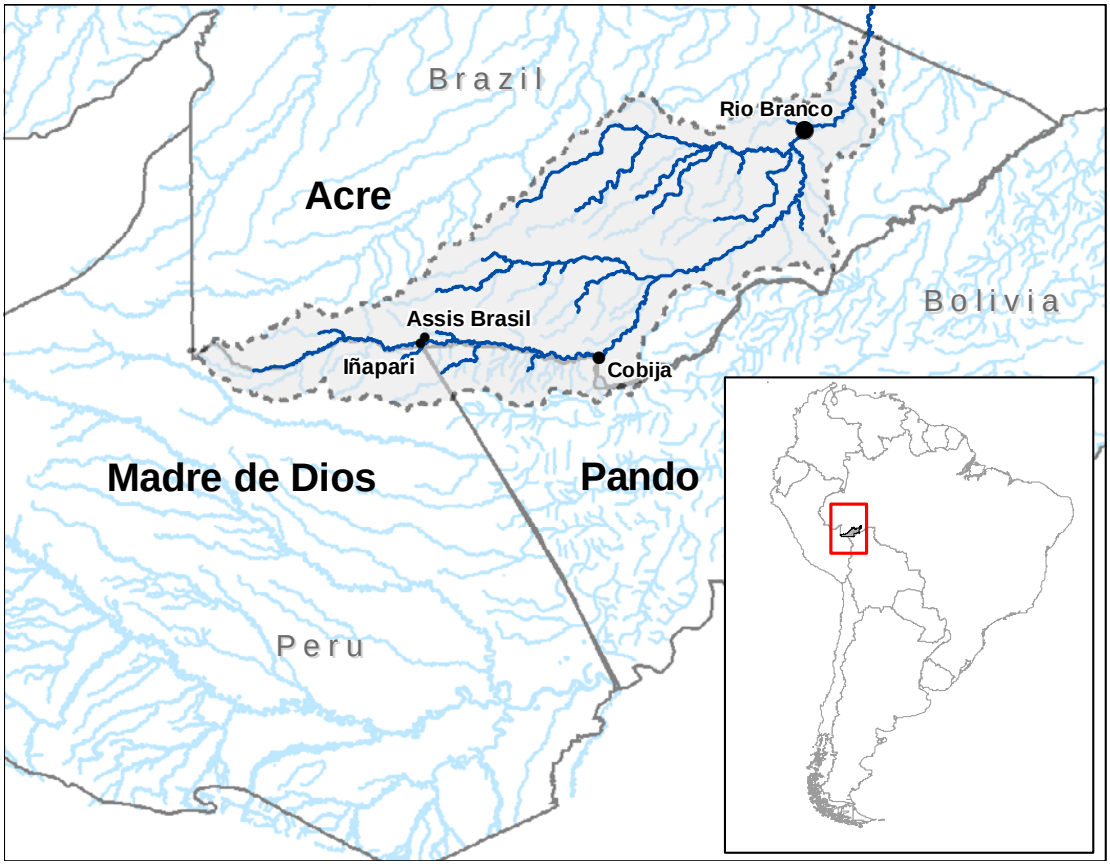

Figure 1-3. A map of the Acre River watershed and its major population centers.

Approximately three weeks into my stay in San Pedro, I contracted a boat in order to visit my second research site, the community of San Miguel de Machineri, located about an hour and a half downriver from San Pedro. I was accompanied by the president of the community of San

[1] Unfortunately, many of the men in the community were not present, which proved to be a minor problem later when I was accused of having arrived to do research in the community without permission or introduction.

Pedro, who had some business to conduct in San Miguel and was on friendly terms with the residents. On that trip, I was only able to meet women in two of the households and the school teacher, but was successful in arranging lodging at the local school. I arrived in San Miguel approximately two weeks later to begin data collection there.

The National Context for Human-Environment Relations in Pando

A detailed discussion of the characteristics and livelihoods systems of each research community will be presented in Chapter 3. However, understanding the national political context is critical to explaining the presence of these communities in Pando in the first place. Their move from the Bolivian highlands and the Brazilian Amazon, respectively, to the Bolivian Amazon was the product of larger-scale factors, including national agrarian reform, a growing indigenous rights movement, and national development strategies.

Since the 1950s, much of Latin America has undergone agrarian reform, during which agricultural land was expropriated from owners and redistributed to peasants (Kay 1998). Bolivia is no exception. The 1953 Agrarian Reform focused on distributing land in western Bolivia, namely the high plains and central valleys which were the most productive region of the country (Urioste 2003). During that time, almost all available land in the Bolivian altiplano was distributed, leaving future residents few options with regards to acquiring land. Furthermore, in the eastern region of the country, the 1953 Agrarian Reform resulted in a system of land concentration in the hands of large estate owners (Urioste 2003).

Between 1955 and 1994, the Bolivian government distributed three million hectares of land in the Bolivian lowlands to colonist farmers (Pacheco 2002). In 1996, in response to problems with corrupt land distribution in the eastern lowlands during the 1970s, the National Agrarian Reform Institute (INRA) Act was passed. Its major function, under pressure from national indigenous rights organizations, has been to achieve proper title to land in lowland

indigenous territories (TCOs) (Urioste 2003). Though some are unhappy with INRA's requirements that all land be communally titled, forcing indigenous people into systems of communal ownership, most agree that the creation of TCOs will help to stop colonization of the lowlands by highland settlers (Urioste 2003). The agrarian reform beginning in the 1950s and its more recent manifestation in the INRA Act, then, is at least partially responsible for the migration of the residents of both San Pedro and San Miguel to the Bolivian Amazon.

In addition to agrarian reform, economic policies have also impacted human-environment relations in the Bolivian lowlands. From 1952-1985, the Bolivian government adopted the development model of Import Substitution Industrialization (ISI), in which incentives were provided to domestic companies to produce goods that would otherwise have to be imported. During this time, investments in the mining sector were used to generate capital that was later invested in national infrastructure, including the construction of roads. The end goal was to open up lowland areas to agricultural production in order to avoid the importation of agricultural products. Colonization schemes were implemented in order to attract people to the lowland regions, leading to increased rates of deforestation (Pacheco 2002). In the end, ISI was not sufficient to support the national economy and Bolivia entered a severe economic recession.

During the 1980s and 1990s, national economic policy focused on a series of structural adjustments that involved fiscal austerity, the reduction of public services, and the liberalization of markets for goods, capital and labor (Gwynne and Kay 1999). The market for land was not liberalized, however, and the Bolivian government continued to distribute land, particularly to large agricultural enterprises. Though some argue that this system of land distribution, along with the elimination of funds for colonization programs, resulted in the closing of frontier areas to small farmers (Pacheco 2002), this was generally only the case in more integrated lowland

areas like the department of Santa Cruz. In Pando, colonization continued to occur (as shown by the arrival of settlers in San Pedro), perhaps because it was one of the least populated and least integrated lowland areas.

The International Context for Human-Environment Relations in Pando

Bolivian communities on the frontier with Peru and Brazil do not live an isolated existence, nor do environmental impacts adhere to arbitrary political boundaries. In fact, with regard to impacts on the shared Acre River watershed, activities spurred by both Peruvian and Brazilian national policy have a greater negative effect than those in Bolivia.

Throughout its history, much of Brazil's colonization strategy has focused on integrating, modernizing and developing the Amazon (Hall 1997; Hecht and Cockburn 1990). The most recent and potentially long-lasting movement in that direction began in the 1960s and continues today. Populating the far reaches of the basin was the military regime's strategy for alleviating social tensions in other areas of Brazil, preventing incursion from other countries and regaining power from regional politicians (Hall 1997). Settlement of the Amazon was encouraged through a system of capital subsidies, which were mostly taken advantage of by entrepreneurs from the southern states. These fiscal incentives resulted in an economic structure characterized by capital-intensive industrial activity and, especially in frontier areas, land-intensive cattle ranches (Maher 1979). Additionally, the government invested in transportation infrastructure, constructing BR 364 to Rondonia and Acre and BR317, the Transoceanic Highway.

Though the ecological impacts of these development programs were varied and generally negative, their primary impact was massive deforestation. By clearing land for cattle grazing, land speculators could establish their claim and obtain legal title. Furthermore, the very nature of cattle ranching necessitated large tracts of cleared land (Lifschitz 1994). Cleared land was also thought to be less susceptible to invasion by squatters.

By the 1990s, government subsidy programs were being cut back because of domestic and international criticism of their role in deforestation. Some tax benefits, credit systems and loopholes still remain, however, and ranching is certainly not on the decline (Hall 1997). Furthermore, increased demand from growing urban centers in the Amazon ensures a market for livestock, thus making it a good investment (Faminow 1997).

In Acre, these policies have resulted in large-scale deforestation. By 1993, 7% of Acre had been deforested (Fearnside 1993), mostly along roads (Malingreau and Tucker 1988). The percentage is likely much greater today, as the Brazilian government has continued to invest in infrastructural development, including highway paving. Along the stretch of the Transoceanic Highway that parallels the Acre River from Assis Brasil to Brasileia, cattle ranches lie side by side, virtually uninterrupted. From the river itself, on the stretch between San Pedro and San Miguel, one can see that the Brazilian side of the bank has been almost entirely deforested (Figure 1-4).

While the Brazilian Amazon has been the focus of national integration programs for decades, it has been only recently that the Peruvian Amazon has been the subject of any development efforts. Agriculture in Madre de Dios has been strongly influenced by national agrarian policy (Alvarez and Naughton-Treves 2003). From 1985-1990, the agricultural frontier expanded in the area around Puerto Maldonado due to the pro-agriculture policies of then president Alan Garcia. These policies provided easy access to credit and land titles, promoted farmer's cooperatives and offered guaranteed markets for staple crops. As in Brazil, the policies were also part of a strategy to populate the Amazon region (Alvarez and Naughton-Treves 2003). Immigrants from the highlands quickly arrived and settled along the roads and rivers of the

region. Deforestation was at its height during this period, concentrated along the road from Cuzco and the road to Brazil.

Figure 1-4. Looking upstream on the Acre River. To the left is Bolivia; to the right is Brazil. Note that the Bolivian side remains largely forested, while the Brazilian side has been deforested for cattle ranching.

This situation changed in 1990 when Alberto Fujimori came into office. His neoliberal economic policies included an end to the credit and subsidy system, new taxes on agricultural products, and a dismantling of the agrarian associations. Deforestation slowed as agricultural credit dried up, and settlers who could no longer afford to farm along the roads moved to river areas where more land was available. Interestingly, deforestation along rivers increased in only some areas; in most locations deforestation rates stayed constant (Alvarez and Naughton-Treves 2003).

Wood (primarily mahogany) is the main product exported from the upper Madre de Dios region. Loggers are now moving up tributaries of the Madre de Dios River in search of new sources (Goulding et al. 2003). Though logging has not become a major issue in the border

region yet, it is only a matter of time before it does. Interestingly, Madre de Dios is the only MAP department that is facing serious problems from commercial logging.

The planned paving of the Transoceanic Highway through Madre de Dios will have enormous impacts in the MAP region. Easier access will ensure an influx of people from the highlands and increasing deforestation rates can be expected (Alvarez and Naughton-Treves 2003).

Though it may seem contradictory to the bleak picture painted above, policies and governance at various scales do not always result in environmental devastation. In a political ecology analysis, both the good and the bad must be evaluated. A bright side to the growing problems in the MAP region is the current administration in Acre, the self-titled "Forest Government" (Kainer et al. 2003). Governor Jorge Viana is a forester with strong ties to the rubber tapper movement via the Workers Party, which was formed by the tappers and others in 1990. The current Brazilian Minister of the Environment is the former Acrean senator Marina da Silva, whose parents were rubber tappers. The administration is dedicated to alternative and sustainable development, and has detailed plans to address pressures created by road construction, expanded ranching and logging and conflicts over land and resource tenure (Kainer et al. 2003). Furthermore, academics, NGOs, and local governments in the MAP region as a whole have begun to meet on a regular basis to discuss cooperative management of the region's resources. While it is still too early to tell, this effort could result in a functional plan to address the future of human-environment relations in this area, including the protection of water resources.

Organization of Thesis

Following this introduction, this thesis is presented in six chapters. In Chapter 2, I will discuss the research methods employed. Chapter 3 provides a sketch of the research communities

including similarities and differences in livelihood systems. In Chapter 4, I will discuss the use of aquatic resources, the conceptualization of river resources (defined hereafter as both aquatic and riparian resources), and systems of riparian zone management in each community. Chapter 5 will discuss the existence of cooperative intra-community and inter-community resource management strategies. Chapter 6 will focus on current and future perceptions of water quality, and on the health impacts of contaminated water. In the final chapter, I will revisit my research objectives with a focus on exploring the potential for future collaborative management of river resources in the study area.

CHAPTER 2
RESEARCH METHODS

My research was conducted over a 12-week period during the summer of 2004. The objective was to determine how two Bolivian communities in the Acre River basin utilize and manage river resources (including riparian areas, wetlands and floodplains) and whether features favorable to collective action for the protection of these resources exist. Specific research objectives and hypotheses were discussed in the previous chapter. In order to address these objectives and hypotheses, six research methodologies were employed.

Due to the small size of the communities in which research was conducted (22 households and 5 households, respectively), I was able to easily contact each household multiple times. This allowed for the use of various methodologies, which allowed me to approach my research objectives from a variety of perspectives. Methodologies employed included participant observation, household interviews, freelisting, participatory mapping, GPS data collection, and a food log (in one community).

Participant Observation

Perhaps the most fundamental research technique to anthropologists is participant observation, so I will begin with that. Much of my time in Bolivia was spent simply "hanging out" (Bernard 2002), making my presence known and trying to understand the rhythm of life. Upon arriving in each community, I spent the first week walking around, drawing informal maps, talking to the residents, attending soccer games, and sitting by the river to watch the children play. I did not take notes in public places, in order to not make people feel as though they were being evaluated. When I had a private moment, I would jot a few key words down in a notebook and later elaborate upon what I observed in my field notes or journal. Ultimately, the

data collected through participant observation allowed me to gauge the accuracy of the information gathered through other methodologies.

Household Interviews

Within a week of arriving in each community, I conducted a census, which provided demographic data and, more importantly, gave me an excuse to talk to someone in every household. I was also able to explain the reason for my presence in the communities, which I was asked to do rather frequently, particularly in San Pedro.

While I worked on the census of each community, I began to make appointments with various households for what would become the centerpiece of my study – in-depth semi-structured interviews. I was as honest as possible about the estimated length of the interview (one to two hours per household) because I wanted a full commitment to complete the interview from both heads of household. I also told them that we could conduct the interview in multiple sessions if they did not have one sufficient block of time (and indeed did so in a number of cases).

My interview protocol (Appendix A) contained seven sections and was structured in a way that addressed each of the objectives of my study. Additionally, I attempted to begin the interview with easier questions, proceed to questions that required more detailed responses, and conclude with questions that required longer answers but less detail. Questions were either open-ended or required a yes/no response.

Before conducting any interviews, I first discussed the interview protocol with a local informant who was not a community member and thus would not be a participant in my study. She helped me both with translation and in wording questions in a way that would be understandable to the interviewees.

Interviews were usually conducted at the homes of the participants (though four were conducted at the locations at which I was living). If possible, both the male and female heads of household were present and participated in the interview (exceptions included households with a single head and households in which one of the heads was not present in the community). With the permission of the interviewees, all interviews were recorded on a Sony minidisc recorder. In total, I conducted interviews with every household but one in San Pedro (21 in total) and with every household in San Miguel (five in total).

The first section of the interview dealt with questions regarding the history of each family: when they arrived in the community, where they came from, why they chose to move to that community. These questions were intended to put the participants at ease with the recording device, get them talking about something with which they were familiar, and give me an idea of the geographic diversity of each community and the factors that motivated them to settle in this area of Bolivia.

Section two involved household structure and kinship networks: how many people currently live in the household, whether there were adult children who did not live at home, and familial relationships to other households in the community. These questions were intended to address my fifth research objective in that they would give me a sense of the interconnectedness of each community, which could be an indicator of the potential for people to work together to collectively manage resources.

The third section of the interview focused on the socioeconomic status of each household and contained questions about educational level, income generating activities, total annual income, consumer items owned, livestock owned, access to water and electricity, and debts. The intent of these questions was to form a complete picture of the demography and economic status

of each household. This was perhaps the most challenging section of the interview for the participants, as it required a detailed breakdown of sources of income. In fact, in many cases, despite my best attempts, it was impossible to arrive at a concrete estimate of annual income. In cases where I could sense that the participants were becoming overly frustrated with my persistent probing, I reverted to one of two tactics: 1) requesting an estimate of the amount of money spent on a daily or weekly basis to support the family (which is a very rough equivalent of total income in households that live at a subsistence level) or 2) abandoning the question entirely.

Section four involved questions about livelihood systems and agricultural practices. This was the longest and perhaps most important section of the interview, in the sense that it was intended to promote an in-depth discussion about systems of agricultural production, use of and/or protection of riparian areas (Objective 2), dependence upon river resources (Objective 1), and household water use (Objective 1).

Section five of the interview contained questions about governance of natural resources within and between communities in the watershed, and perceptions of upstream-downstream connections among communities along the Acre River. These questions addressed Objectives 2, 4 and 5.

The sixth section addressed intra- and intercommunity dynamics. Questions focused on the participants' perceptions of the strengths and weaknesses of their communities, mechanisms for conflict resolution, types of community organizations, and relationships between communities. The intent of this section was to provide a measure of community and regional cohesiveness and/or solidarity that would promote or limit cooperative management of river resources (Objective 5).

The final section of the interview dealt with perceptions of current and future water quality, health problems, individual strategies for protecting water quality (including how to deal with human waste and household garbage), perceptions of the importance of riparian areas, and attitudes about a potential watershed management plant that might ask landowners to maintain riparian buffer zones or engage in reforestation efforts (Objective 3).

Upon my return to the United States, I transcribed each interview and input the responses by household and participant into a Microsoft Excel spreadsheet. The resulting item by respondent matrix allowed me to tabulate and summarize the key elements from each response.

Freelisting

A freelisting exercise was conducted with all but two adults (35 total) in San Pedro de Bolpebra and with all available heads of household (seven total) in San Miguel de Machineri. Freelisting is an anthropological technique designed to elicit a list of items that form a particular cultural domain. In this case, each person was asked to list all of the natural resources that are found in rivers, streams and riparian areas. The results from freelisting can provide a measure of the familiarity with and importance of river resources to each community (Objective 1).

The original freelists were analyzed in Microsoft Excel. Further analysis was conducted in Anthropac.

Participatory Mapping

One of the most interesting and entertaining methodologies employed was participatory mapping. This technique is a popular tool in participatory rural appraisals and can generate spatial information about resource use, land distribution, and agricultural activities (Nemarundwe and Richards 2002) (Objectives 1 and 2).

The exercise was conducted with each household at a separate time from the interviews and freelists. To begin, I solicited the help of three community members in San Pedro in drawing

a base map of the community that included each family's agricultural property. In San Miguel, I was able to create the base map on my own because the land ownership is not as structured and because the community is much smaller. Each base map included the Acre River and any other major geographical features (roads, property lines, locations of houses, international borders). I then visited each household and asked the head of household (in most cases male, but sometimes female) to draw the rivers and streams on their property, where their agricultural fields were located, where specific crops were planted, and any riparian buffers they had maintained near water bodies (Figure 2-1). While they worked, I discussed their drawing with them and added notes that quantified the number of hectares being drawn, meters of riparian buffers, and meters of streams and rivers that flowed through their property. In addition to providing a visual reflection of land-use patterns in these communities, these participatory maps were intended to allow the verification of information collected during the semi-structured interviews. The final participatory maps are included in Appendix B.

Figure 2-1. A community member in San Pedro works on the participatory map.

In creating the map for San Pedro, I encountered some difficulties and learned some important lessons. My original intention was to call a community meeting and ask all of the households to work collaboratively to create the map. However, due to a variety of circumstances beyond my control, the meeting time was not communicated to the community, nor was the importance of the attendance of the person in charge of agricultural production for the household properly emphasized. When the meeting finally coalesced, therefore, it was late in the evening and primarily attended by the female heads of household, who had very little knowledge about the locations of streams and crops or the existence of riparian buffer zones, as it was generally the men's area of expertise. I realized that it would be best to cancel the meeting and to visit each house individually. While this was a frustrating experience for me and for the attendees of the meeting, I learned a valuable lesson and approached the mapping process in San Miguel differently.

Global Positioning System (GPS) Data

The use of GPS and Geographic Information Systems (GIS) is becoming ubiquitous in both the natural and the social sciences. I therefore decided to collect data on the locations of each house and bathroom to determine how far from water sources these features were and whether the potential existed for floods to cause contamination events (Objective 2). These data were analyzed in ERDAS IMAGINE.

Food Log

As will be discussed in Chapter 3, the residents of San Pedro de Bolpebra have easy access to the Brazilian city of Assis Brasil. They are therefore less dependent on river resources for sustenance and are also accustomed to purchasing food by weight. When I asked families in San Pedro to quantify the amount of various food items that they consume on a weekly basis, they were easily able to answer the question. San Miguel, on the other hand, is a much more isolated

community and the residents are therefore more dependent on natural resources for food supply. Hunting and fishing are almost daily activities, but conducted at random and only when necessary. It proved difficult during my interviews to arrive at a concrete estimate of the amount of fish or wild game consumed on a weekly basis. I arrived at the conclusion that creating a daily food log for each family was my only option for this type of data collection. I visited three families (the only ones that were available) once per day for eight days to record what they had eaten for each meal on the previous day and how much of each type of food they had consumed. Food data from both communities will be used to understand the extent to which each community depends upon natural resources for survival (Objective 1).

CHAPTER 3
COMMUNITY CHARACTERISTICS AND LIVELIHOOD SYSTEMS

The relationship between a local population and a natural resource of interest (in this case, water) is only one part of the complex puzzle that forms a group's livelihood system. In light of this fact, I will begin the presentation of my research results with an ethnographic sketch of each community. I will attempt to demonstrate that the communities of San Pedro de Bolpebra and San Miguel de Machineri are different in fundamental and important ways, a fact that has implications both on their relationship to aquatic resources and on the potential for future collaborative watershed management.

San Pedro de Bolpebra

San Pedro de Bolpebra is located, quite literally, at the northwestern tip of Bolivia. From the banks of the Acre River, one can see and, in under 20 minutes, walk to the communities of Iñapari, Peru (reported population: approximately 1,000 people) and Assis Brasil, Brazil (reported population: 6,000-12,000 people). San Pedro itself is inhabited by settlers from the highland area of Bolivia. The community has a population of 102, residing in 22 households.[2] On average, family size is relatively small, with a mean of 3.78 children (range of 0-8, median of 3). Adults in the community have an average of 7.38 years of education.

Approximately half (52.5%) of the households originate from the department of Tarija, Bolivia's southernmost department. The remainder of the community is composed of families from the highland departments of Oruro (5%), La Paz (15%), Chuquisaca (12.5%), and Cochabamba (5%) and the lowland departments of Pando (7.5%) and Beni (2.5%). As recounted to me by various community members, the original group of ten families arrived in San Pedro in 1992 after a failed attempt at settlement in another area of Pando. Leaders of the original group

[2] Data for this study were collected from 21 households.

petitioned authorities in the nation's capital, La Paz, for a land grant in the Amazon region. According to them, Tarija was experiencing a shortage of land and employment opportunities. The settlers thought that they would fare better with land in the Amazon, even though most had little experience with farming. In Tarija, many had been shopkeepers, taxi drivers, carpenters, and other types of urban laborers.

The Bolivian government granted the settlers communal title to an area of approximately 30,000 hectares. According to requirements of the Bolivian agrarian law, each family was allocated a territory of no more than 500 hectares. In order to maintain informal ownership of their lot, each family has to make "productive" use of the land, meaning that it must fulfill its social function by being used for agricultural purposes (for an historical perspective on the Social Function Doctrine and its role in land reform in Latin America, see Ankersen and Ruppert 2006). Any land that is unused for a period of more than three months can be taken away and reallocated to another community member. Enforcement of this policy would be non-existent if the community itself did not take it on, encouraged by individuals who either want the land for themselves or are trying to punish families who have left the community to pursue work elsewhere. While this procedure is not followed often, it has indeed occurred. In fact, an attempt to reclaim a lot belonging to one of the original founders of the community was one of the major conflicts that I witnessed during my stay in San Pedro.

Upon the founding of San Pedro, the community was not connected by road to the rest of Bolivia. The settlers immediately began cutting a trail that would later become a poorly-maintained dirt "highway" to the departmental capital, Cobija. From the other direction, tractors were also cutting a road through the jungle. As is often the case, with roads come people, and San Pedro lost approximately 8,000 hectares of its original territory to squatters. In addition, in

1993 a pro-indigenous national government came into power and, under pressure from a growing indigenous rights movement, created a number of indigenous territories known as Original Communal Lands (*Tierras Comunitarias de Origen* or TCOs) (Padwe 2001). During this time, the Yaminahua-Machineri TCO was formed in Pando and allocated a territory of 22,000 hectares, approximately half of which was land that had originally been granted to the community of San Pedro. Currently, the total territory of San Pedro is approximately 10,000 hectares.

The community of San Pedro is partially integrated into the market economy. Individuals reported engaging in a variety of activities to earn a living (Figure 3-1). A number of community members own stores for the purpose of selling inexpensive import goods (mainly electronics, plastics, and clothing) to the nearby Peruvians and Brazilians. These stores are located on the riverbank (*el Puerto* or the port) directly across the Acre River from Assis Brasil, making them easily accessible to their Brazilian and Peruvian customers. The town center, containing the majority of the planed timber and tin or thatch roof houses and the school (Figure 3-2), lies approximately half a mile downstream from the port and slightly inland. Community members who live in town make their living through a diverse set of strategies, including small-scale agriculture and/or cattle ranching both for subsistence and for sale (sometimes in combination); teaching in the local school; carpentry/handyman work (and were working on government funded improvement projects in the community during the summer of 2004); and working as street vendors in Assis Brasil.[3] Community members who split their time between San Pedro and

[3] Assis Brasil is connected to the rest of Brazil via the Transoceanic Highway, which runs across Brazil and over the Peruvian Andes, terminating at the Pacific Ocean. In 2001, the Transoceanic Highway was paved as far as Assis Brasil, which has facilitated in-migration leading to rapid population growth in the area. My informants estimated that Assis Brasil currently has a population of between 6,000 and 12,000 people. The difference between the communities on the Bolivian side versus those on the Brazilian side of the Acre River is stark. Assis Brasil has restaurants, grocery stores, low-end hotels, telephone service, automobiles, and other amenities. San Pedro has none of these things.

the departmental capital of Cobija work as taxi drivers, restaurateurs, or serve in municipal governmental posts. In addition to these activities, some community members also participate in Brazil nut sales and illegal timber harvesting for supplemental income. The mean annual household income is 14,601 Bolivianos (approximately US$1827), though the range is wide, depending on type of employment (2,098 - 54,548 Bolivianos).

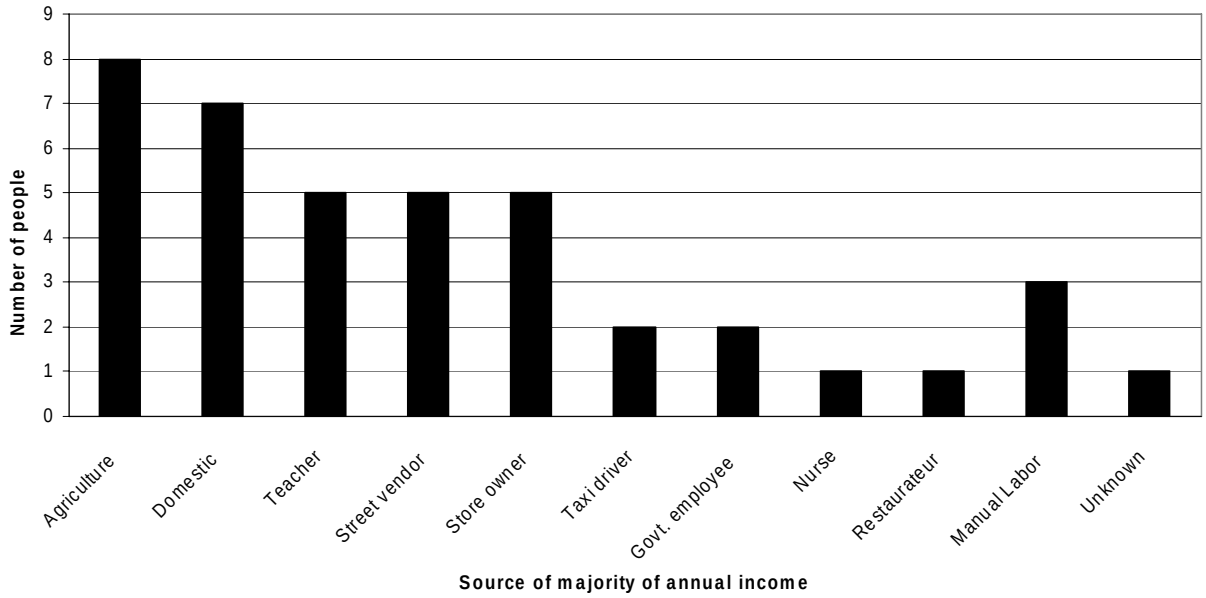

Figure 3-1. Employment in San Pedro. Note that the category "Domestic" consists of non-income generating stay-at-home wives and mothers

Figure 3-2. Typical houses in San Pedro.

Sixteen of the 21 households interviewed own livestock, including chickens, pigs, horses, oxen, sheep, turkeys and ducks. Six households reported owning cattle, though herd size is relatively small, with an average of 14 head. Livestock are used primarily for personal consumption or, in the case of horses and oxen, for transportation. Some households reported occasionally selling livestock, but this is not a frequent occurrence. As one community member stated, "Twenty cows aren't worth selling. One sells one to cover expenses, but more than anything they are for our own consumption…That's the only thing that a *campesino* has. Other people have savings, banks but a *campesino* has his animals as savings."

As stated above, most community members receive informal ownership of a maximum of 500 hectares of land in addition to a small lot in the "urban area" upon which they can build their house. Seventeen of the 21 households interviewed "owned" a lot that ranged in size from 270 to 500 hectares. One household owned 680 hectares because it had purchased land (albeit illegally) from a former community member. Two of the remaining three households were not interested in owning agricultural land and one was a new arrival and was waiting for land to become available.

Though the total area of land owned per household is relatively large, only a small portion of each household's lot has been cleared for agriculture or cattle ranching (Figure 3-3). Of the 17 households that own land and have cleared an area for agricultural use, the average total area cleared was only 9.5 hectares per household, though this number is skewed by three households that have cleared a large area for cattle pasture. If those households are eliminated from the sample, the average cleared area drops to 4.9 hectares per household. Furthermore, the total area cleared is often not contiguous, resulting in scattering of small fields. The average individual

field size, eliminating the three large cattle pastures, is 4.43 hectares with a range of 0.75-15 hectares.

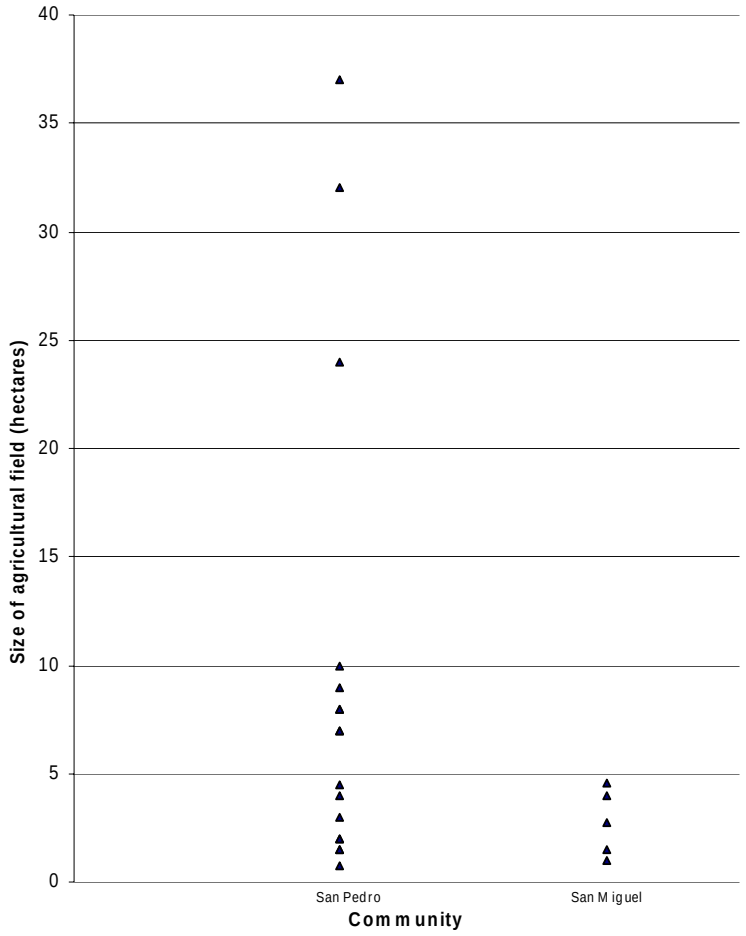

Figure 3-3. Total area under agricultural production per household.

Agriculturalists in San Pedro grow a variety of crops both for sale and for personal consumption (Figures 3-4 and 3-5). The quantity of products sold varies from year to year, depending on crop yield and household requirements. Watering needs are almost exclusively met by rainfall, though three households reported occasionally using a community-owned pump to water more delicate crops like tomatoes and peppers. To supplement their own production, every household obtains much of its daily food supply, particularly meat, canned, and processed foods, from merchants in Assis Brasil.

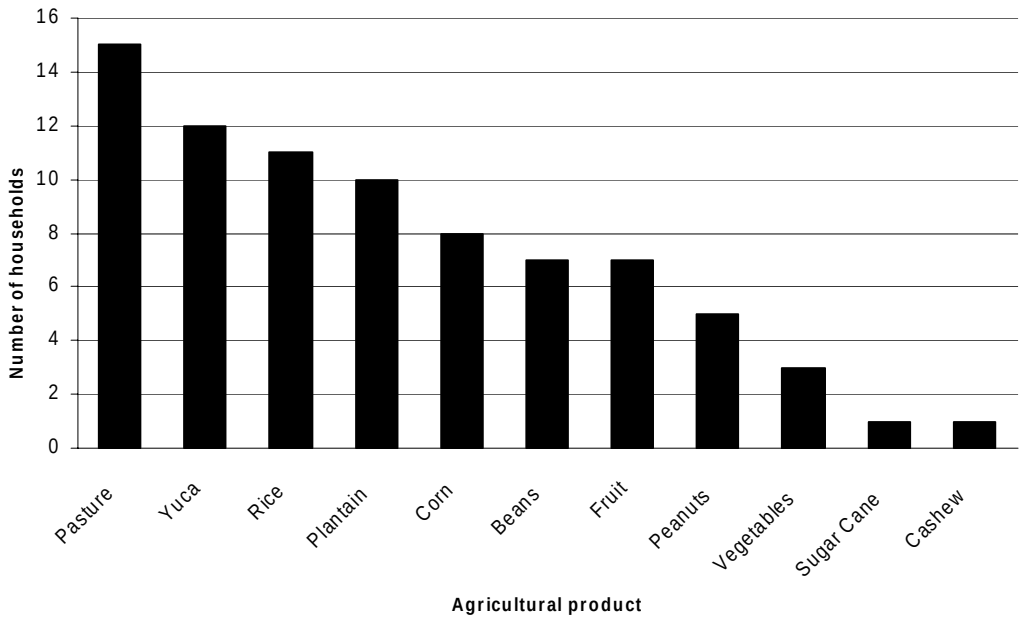

Figure 3-4. Number of households that grow each agricultural product in San Pedro.

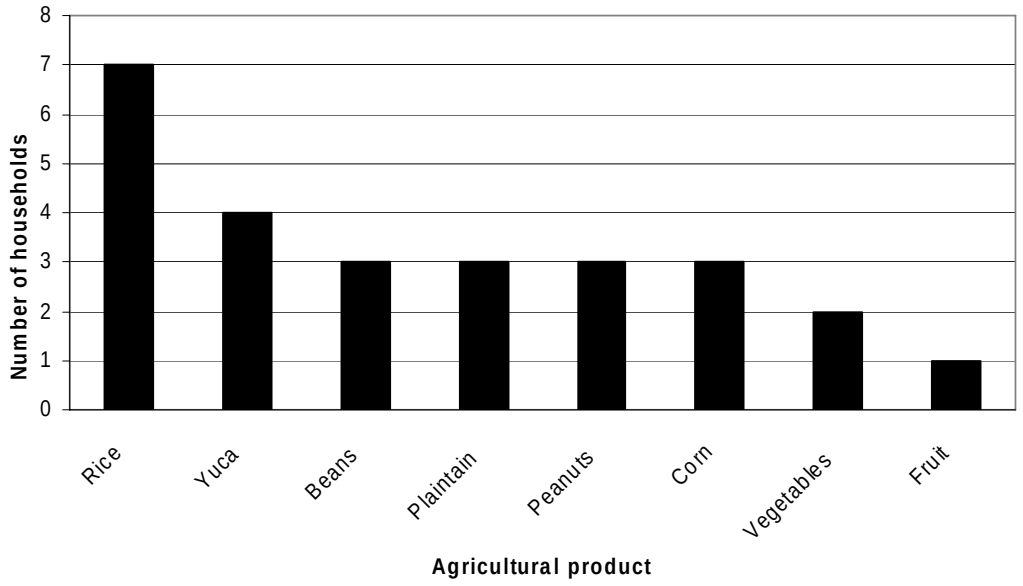

Figure 3-5. Number of households that sell each agricultural product in San Pedro.

San Pedro is still undergoing a process of infrastructural development. While the standard soccer field is present, the community still lacks a fundamental element of most Latin American towns – a central plaza. The three roads in the town are little more than wide grass paths (Figure

3-6), which is currently sufficient as no one owns a car and there are no local bridges that connect Bolivia with Peru or Brazil. Recently, running water from a nearby spring was piped to 15 of the 16 houses in the main community. Due to a lack of funds for gasoline, however, the pump is only run once per week for half an hour. The four houses located at the port do not have running water and must retrieve their drinking water from Assis Brasil either by purchasing bottled water or by filling their own jugs from the pipes that reach the river bank. Electricity for the community is purchased from Peru and transported via a patchwork of cables. All but two houses have access to electricity and there were immediate plans for connecting those remaining houses. There is no phone service, thus all contact with the departmental capital is conducted via radio. A new health center was being built during the summer of 2004 and is staffed by the community nurse and occasionally visited by a doctor who divides his time among various rural communities.

Figure 3-6. A picture of a main road in San Pedro. The three roads in San Pedro are simply wide grass paths. No households own cars.

Much of San Pedro's hope for future development rests on the highly anticipated improvement of the road to Cobija. Currently, the residents feel deeply isolated. With little access to markets in their own country, their only choice for long-term survival in the area is the

production of items desired by nearby consumers – cattle and timber. Although cattle ranching has not yet overtaken the area, many families in San Pedro hope to eventually own cattle or to expand their herds.

A second issue that arises from the lack of reliable road access in San Pedro is that the community members have difficulty reaching their 500 hectare properties. The lots begin about two kilometers from town and flank either side of the currently unimproved road for as far as 22 kilometers, meaning that that many community members cannot access their land on a daily basis. Eight households have resorted to farming in areas within the community's urban area, with fields ranging in size from 0.25 to 6 hectares. Much of the urban area lies along the Acre River, so many of the agricultural fields are, by default, directly adjacent to the river. Once the road is completed, the residents of San Pedro anticipate better access to their land (via automobile) and, more importantly, to regional and national markets for their agricultural products.

San Miguel de Machineri

The second research community, San Miguel de Machineri, is located on the Acre River approximately 1.5 hours downstream from San Pedro by motorized canoe (an estimated distance of 16 kilometers) in the northwestern corner of the Yaminahua-Machineri TCO. Residents of San Miguel are members of the Machineri indigenous group, originally from the Sena Madureira region of Brazil (Herbas 2000). In 2004, the community had a population of 23 people in five households, though this number (both of people and households) tends to vary from year to year. Household size is small, with an average of 3.14 children (range of 1-10, median of 1), but each household in San Miguel is related to the others by way of one of the heads of household. Frequently, members of these families depart for extended periods of time and family members

who reside outside of the community arrive for lengthy visits. Adults in the community have an average of 2 years of education; at least five (of nine) are illiterate or only partially literate.

Though the residents of San Pedro claim that upon their arrival to the area in 1992, San Miguel was uninhabited, some residents of San Miguel state that they have lived in the area for approximately 20 years. This time period is difficult to confirm, as the earliest migrants do not remember the year in which they arrived in Bolivia. Based on oral histories regarding the number of houses they have built and fields they have planted, however, a time-line of approximately 20 years seems feasible. Other residents have arrived more recently, particularly since the founding of the TCO. All residents of San Miguel speak Portuguese, four adults speak Machineri (the indigenous language), and one adult speaks some Spanish. With the exception of one, children and young adults in the community do not speak Machineri, but all speak Portuguese and most speak at least some Spanish, as the school teacher in the community is Bolivian and conducts classes in Spanish.

Land in the TCO is communally owned and new residents must first seek permission from the community before they settle there. While there may be federal restrictions as to the ethnic origin of TCO residents, this did not seem to be the case at the local level. It seemed that anyone, regardless of indigenous status, could be granted permission to settle in the community if they met the community's approval. Practically speaking, as has been the pattern in the past it is likely that new residents would be connected in some familial way to current residents and thus would likely be Machineri. Houses, constructed of palm trunks and thatch (Figure 3-7), are relatively distant from one another. Walking time varies from 5-15 minutes between households. Each household simply chooses an area in the vicinity of their house in which to create their agricultural fields.

Figure 3-7. Typical houses in San Miguel.

Households depend upon subsistence agriculture (Figure 3-8), hunting, and fishing for daily survival. In agriculture, families practice shifting cultivation. Once a field is harvested, natural vegetation is allowed to regenerate for three to five years. After that time the soil is fertilized by clearing and burning the field for reuse.

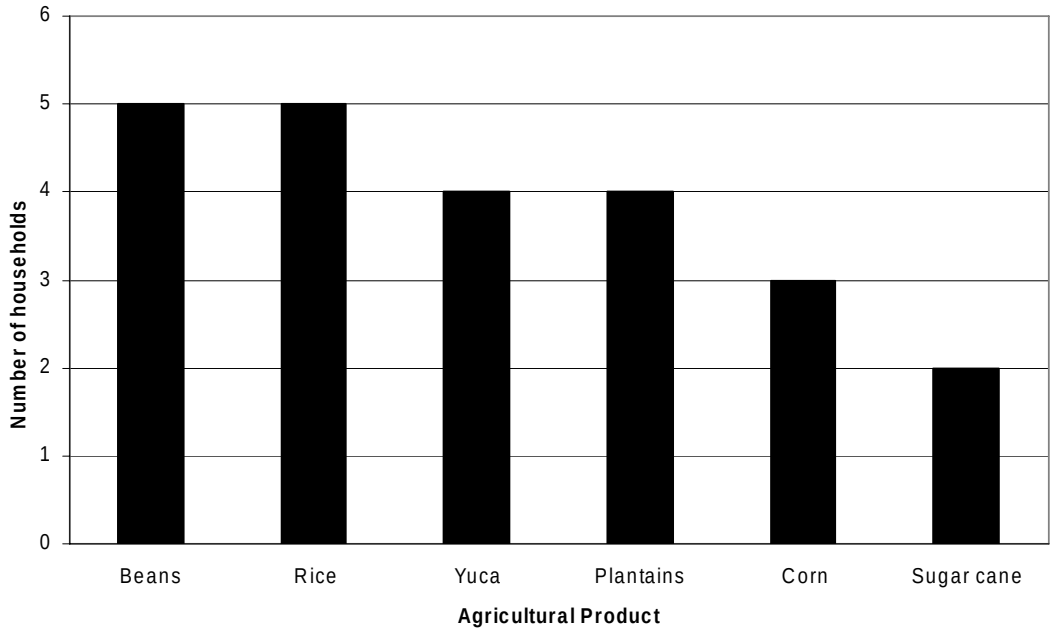

Figure 3-8. Number of households that grow each agricultural product in San Miguel.

In comparison to San Pedro, both the total cleared agricultural area per household and the individual field sizes are much smaller in San Miguel (see Figure 3-3). The average cleared area for agricultural production is 2.44 hectares/household, and the average contiguous cleared area is just 1.23 hectares.

As in San Pedro, each household owns some kind of livestock, though at a much smaller scale. Each family owns a number of chickens, and some also own ducks and pigs. In contrast to San Pedro, only one household owns cattle. However, the cattle are currently housed on a ranch in Brazil and the owner had no immediate plans to transport them to San Miguel, though he did have pasture planted in preparation for their arrival. One additional family hopes to own cattle in the future.

To supplement subsistence activities, residents of San Miguel employ a number of other livelihood strategies. Five men (one per household, though not necessarily the head of household) occasionally work as day laborers in Brazil, earning an income of approximately $3/day. Two households reported occasionally selling wild game and/or fish to their Brazilian neighbors and at least four of the households sell a portion of their agricultural harvest (Figure 3-9). In addition, during the early months of the year, every household collects Brazil nuts and sells them to both Bolivian and Brazilian processors. Average annual household income in San Miguel is 10,158 Bolivianos (approximately US$1,271). Although it cannot be argued, then, that the residents of San Miguel are not integrated into the market economy, the extent to which they engage and depend on outside forces for survival is much more limited than in San Pedro. For this reason, the lack of road access is not as frequent a topic of conversation in San Miguel and does not seem to cause the same feeling of isolation as it does in San Pedro.

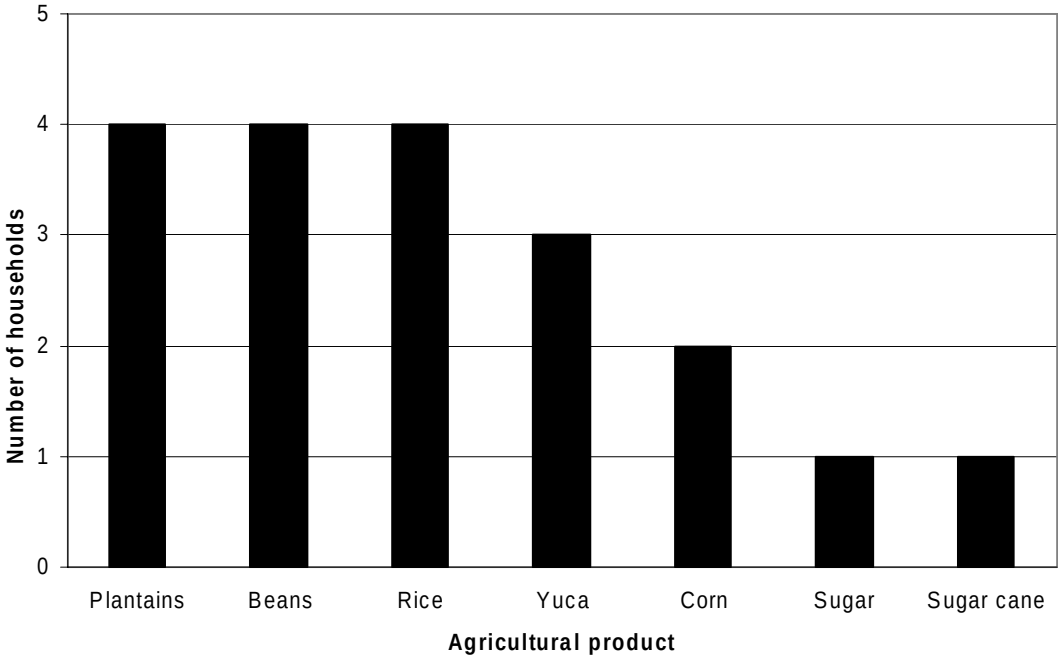

Figure 3-9. Number of households that sell each agricultural product in San Miguel.

San Miguel is substantially less infrastructurally developed than San Pedro. It does not have electricity, running water, or telephone service. Discussions regarding the installation of water pipes have occurred, though no immediate plans have been made. For now, each household has access to a small stream near their house, which they use for bathing, cooking, and washing clothes. In early 2004, the community was given a radio, powered by a combination of solar energy and a car battery, which they use to communicate with other communities and with the Indigenous Center for the Original Villages of Amazonian Pando (CIPOAP), located in Cobija.

Despite its small size, it is clear that San Miguel functions as a community, a fact that allows for a comparison of resource use and management efforts with the larger community of San Pedro. First, the community is recognized as such by the government of Bolivia and has received aid in the form of a primary school based on this designation. Second, like all other

official communities in Bolivia, under the Popular Participation Law the community has elected a community council (*Organización Territorial de Base)*, the president of which represents the community at regional functions. It is also a member of CIPOAP, which represents all indigenous communities in Pando. Finally, San Miguel has not always been as small as it is now. In the mid-1990s, the community consisted of 16 households, many of which left the area due to land conflicts with settlers from San Pedro (Herbas 2000). By 1998, the population had shrunk to seven households. There is no indication that the community will retain its small size, however, as the population has tended to grow and shrink over time.

Conclusion

As can be seen from the preceding discussion, San Pedro and San Miguel are distinct in terms of their size, ethnic origins, social organization, and livelihood strategies. One is a colonist community, composed of residents from many regions of Bolivia. While some kinship connections exist, most households are relatively independent of each other in both personal and practical matters. Households in San Pedro make a living in a relatively wide variety of ways but, more often than not, not through the exploitation of natural resources. This variety of livelihood strategies is made possible by San Pedro's location near population centers in Peru and Brazil.

Households in San Miguel, on the other hand, are intricately connected via kin networks and function in a more cooperative manner. Furthermore, due to their greater isolation from major population centers, households in San Miguel tend to rely on natural resources for survival to a greater extent. The following section will discuss additional differences in these communities' use of aquatic resources and riparian areas.

CHAPTER 4
AQUATIC AND RIPARIAN RESOURCES

Use of Aquatic Resources

The dependence of indigenous and colonist Amazonian communities on freshwater resources has been previously documented (McClain et al. 2001; McClain and Cossío 2003). Therefore, the fact that San Pedro and San Miguel are located near a relatively major water body might lead one to the conclusion that the use of aquatic resources would constitute a major component of their livelihood systems. This did not prove to be the case. Though households in these communities do make use of aquatic resources for drinking water, transportation and food supply, they do not depend as heavily on these resources as one might expect. The following section will discuss the use of aquatic resources, including fishing, transportation, and domestic water supply in each community.

Fishing as a Livelihood Strategy

San Pedro

Households in San Pedro view fishing in much the same way as households in the United States might view it. Fishing is considered an activity in which one might partake on the weekends, for example, as a form of relaxation or to provide variety in the household menu. Some households commented that fishing is not "their custom," meaning that fishing was not a livelihood strategy in their highland departments of origin. Furthermore, a number of households emphasized that fishing, when engaged in, is done solely for household consumption. No households sell fish for profit, though they do occasionally purchase fish from Brazilian fishermen who fish on a larger scale.

Of the 21 households interviewed, 18 reported fishing on occasion, with an average frequency of 13.7 times per year. Some households reported fishing exclusively during the wet

season, as the river is higher and, as one informant stated, the muddy water obscures visibility and prevents the fish from being frightened by the fishermen. All 18 households report fishing with a hook and line, and three also reported fishing with a net on occasion.

In general, yields are small. Households reported catching an average of 2.4 kilos each time they fish (usually less than five fish). Though households reported catching 19 different species of fish, some species are caught more frequently than others (Figure 4-1). Many households also reported purchasing fish on occasion, bringing the total average annual fish consumption to 41.5 kilos/year/household. When compared to previous studies, this quantity is less than expected. For example, colonist households in the Peruvian Amazon reported consuming 145.6 kilos/year of fish (McClain et al. 2001:406).

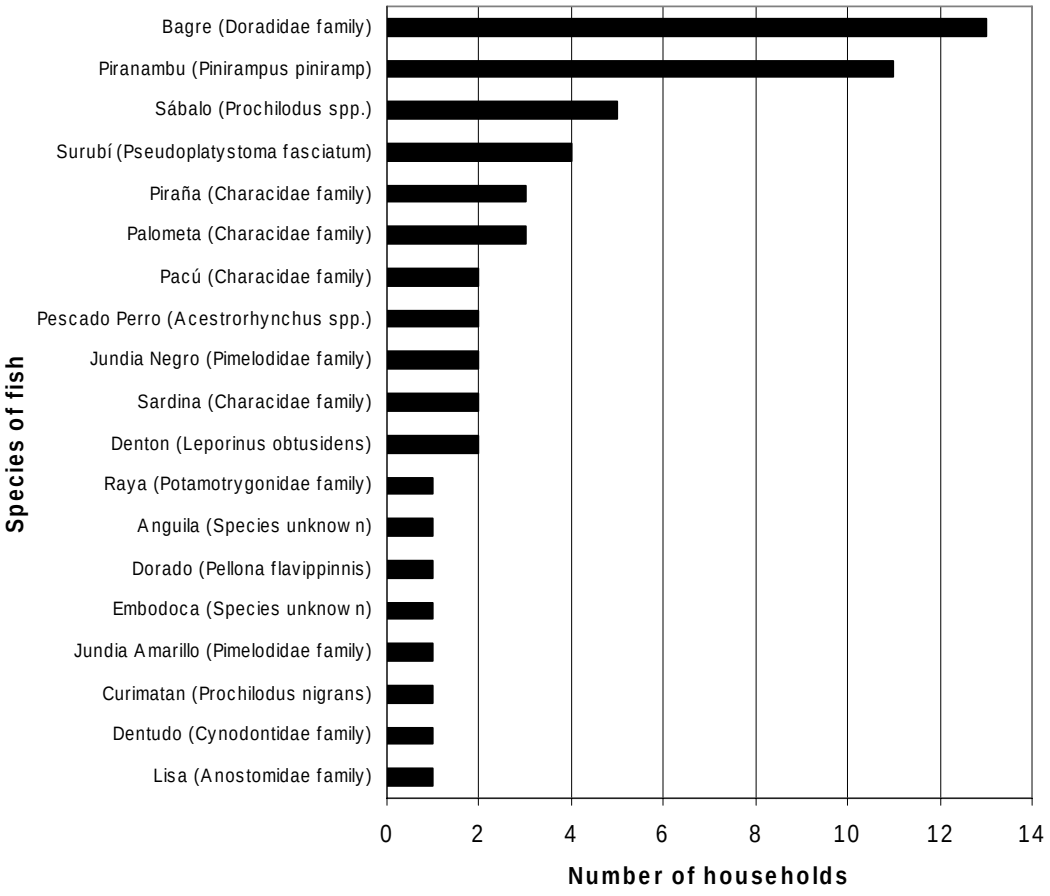

Figure 4-1. Species of fish caught by households in San Pedro.

One measure of a population's dependence on fishing as a livelihood strategy could be the proportion of their protein intake that is satisfied by fish in relation to other types of protein consumed. To this end, households in San Pedro were also asked about hunting practices and purchased meat.

Only four households reported hunting, and infrequently at that. Of the households that hunt, most eat wild game (including deer, peccary, monkey, armadillo, turkey, paca, turtle, and tapir) only a few times a year.

As stated previously, households in San Pedro rely on markets in Assis Brasil for much of their meat supply. Beef and chicken are purchased almost exclusively in Assis Brasil (on occasion a family will slaughter one of their own animals). Households reported consuming approximately 5.6 kilos/week of beef and 6.7 kilos/month of chicken. Pork is reserved for special occasions, such as community celebrations when a pig is slaughtered. Households reported eating an average of 48.4 kilos of pork/year. Households also occasionally purchase processed meats (canned meat and sausage) and many collect eggs from their chickens.

Ultimately, then, fish (including fish purchased from commercial fishermen) constitutes only 9% of the major sources of protein (beef, chicken, pork and fish) consumed by households in San Pedro. This indicates that this community is likely not dependent on river resources for survival, at least with regard to food supply.

San Miguel

Households in San Miguel are more dependent on natural resources than their upstream neighbors in San Pedro. Whether this pattern is explained by isolation from markets or by cultural tradition was not determined through this study, though it seems that a combination of both factors may be at work. Nevertheless, although they make more use of natural resources, families in San Miguel are also less dependent upon fish as a food source than one might expect.

Of the five households in the community, all reported fishing. On average, households fish 2.9 times per week (almost 89 times more frequently than households in San Pedro). Yields are about the same, however, with households reporting an average catch of 2.2 kilos on a good day.[4] As in San Pedro, when compared with previous studies, the quantity of fish consumed in San Miguel is less than expected. If a calculation is made based on data collected from the food log, households in San Miguel consume an average of 189.15 kilos/year of fish. Meanwhile, indigenous households in the Peruvian Amazon reported consuming 249.6 kilos/year of fish (McClain et al. 2001:406).

All households reported fishing with a net (Figure 4-2), and three reported also fishing with a hook and line. The decision to use one technique or the other is based on a number of factors, including the size of the stream, efficiency and personal preference. Smaller streams necessitate fishing with a hook and line because the net can get tangled in underwater logs. One household believed that one can catch more fish with a net (and thus did not ever fish with a hook and line), and one household would switch tactics depending on whether or not the fish were responding to the initial strategy employed.

The species of fish that are caught in San Miguel are somewhat similar to those caught in San Pedro (Figure 4-3). Interestingly, however, residents in San Miguel reported catching fewer species, 14 in total.

[4] It was difficult for households in San Miguel to estimate their weekly fish consumption because their livelihood strategy involves a constantly varying combination of hunting and fishing. If, for example, a household is successful in killing a wild animal, they have no need to hunt again or to fish for several more days. To compensate for these difficulties, I collected data on food consumption for eight days from three of the five households (the other two households were not available for interviewing). During the week that the data were collected, the *total* fish consumption for the three households was only 2.5 kilos. The discrepancy between actual fish consumption and estimates reported during semi-structured interviews might be attributed to memory errors (Bernard 2002) or to the fact that during the week that food data were collected, a supply of staple food items arrived in San Miguel from the Bolivian government as part of a flood relief plan (the community had been flooded in early 2004). These items (noodles, flour, dried milk, etc.) supplemented, and partially substituted for, hunting and fishing during that week.

Figure 4-2. Fishing nets are the most commonly used fishing technology in San Miguel.

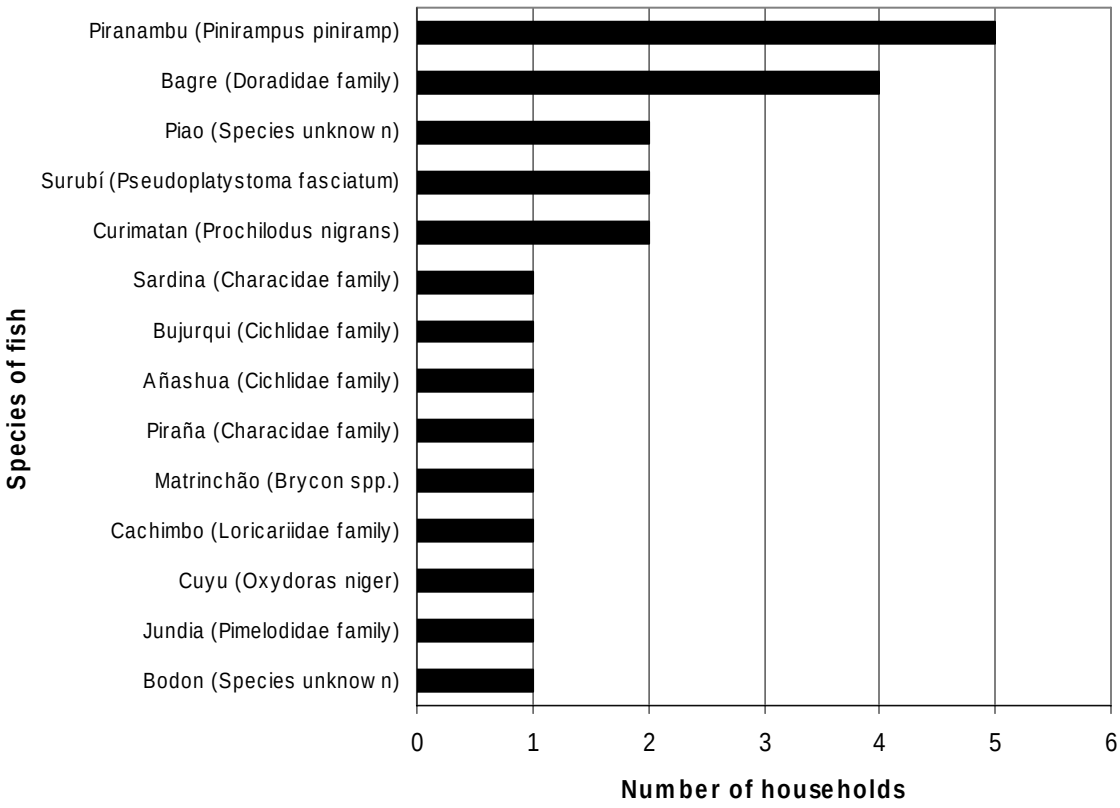

Figure 4-3. Species of fish caught by households in San Miguel.

In addition to fishing more often than households in San Pedro, households in San Miguel also hunt more frequently. All households reported hunting, though it was difficult for them to estimate the average frequency. One household purchased meat from markets in Assis Brasil on occasion because the head of household made frequent trips there to visit his ailing mother.

In total, households reported consuming an average of 7.3 kilos of wild game per week, of which 0-6.4 kilos is composed of fish.[5] Interestingly, without exception, households in San Miguel reported a preference for hunting over fishing. While some households preferred to eat wild game (including deer, monkey, peccary, paca, turkey, armadillo, turtle, tetitu) because of its better flavor, others found hunting to be a more efficient means of providing meat for the household. However, an important limiting factor in hunting is the availability of rifle ammunition, which is expensive to purchase.

In comparison to San Pedro, then, households in San Miguel consume more fish. However, the large majority of their diet is composed of wild game. This fact may indicate that the dependence on aquatic resources for subsistence is not as strong as one might expect. However, the dependence of game species on habitat provided by rivers, streams and riparian areas is an important point to consider in that it establishes a second tier connection between communities and river resources (McClain 1999).

[5] According to the data gathered through the food log, the three families interviewed consumed an average of 4.4 kilos of wild game per household during the eight day period. Animals consumed included white monkey (*Cebus albifrons*), red howler monkey (*Alouatta spp.*), turtle, paca (*Agouti paca*), collared peccary (*Tayassu tajacu)*, white lipped peccary (*Tayassu pecari*), brown agouti (*Dasyprocta variegate*) and wild turkey. One household also killed one of their chickens and was given a domestic pig head. A second household consumed a small quantity of dried ox (*charque de buey).* According to these data, then, fish constituted 15% of the total protein intake during that period, while wild game constituted 77%.

Other Uses of Water Resources

Amazonian river dwellers make use of aquatic resources for more than simply subsistence purposes. Other important uses include transportation and water for domestic consumption. The communities of San Miguel and San Pedro follow this pattern. However, mirroring the lack of dependence on aquatic resources for food discussed above, residents in these communities seem to rely on river resources for transportation and domestic use to a lesser extent than might be expected.

Use of river for transportation

In San Pedro, only two households currently own a motorized canoe that enables them to effectively use the Acre River for transportation. One of these households owns one of the local stores and uses its boat to transport merchandise from Cobija, which is a one- to two-day trip by river. Because of limitations placed on Bolivian citizens for travel and transportation of goods through Brazil along the Transoceanic Highway, merchants in San Pedro have few options for transporting goods other than by river.

The other household that currently owns a motorized canoe uses it exclusively to transport the male head of household to his distant agricultural field and to transport agricultural products back to San Pedro. This household is lucky in that they have access to their 500 hectare lot both from the dirt "highway" and from the river. Lots located on the other side of the road do not have river access, thus restricting the export of agricultural products.

Four households in San Pedro have owned canoes in the past, but have either sold them or lost them to floods or rot. The floods of 2004 were particularly damaging, as they carried away the canoes of two of these households. None of the households in San Pedro use canoes for fishing purposes; if canoes are owned, they are used exclusively for transportation.

In San Miguel, only one household owns a dugout canoe, which is frequently used for fishing. It does not have a motor, thus making it an ineffective means of long distance transportation. The other community in the Yaminahua-Machineri TCO, Puerto Yaminahua, has access to at least one motorized canoe that occasionally stops in San Miguel to pick up or drop off passengers. Otherwise, residents of San Miguel walk to San Pedro or Assis Brasil via the highway or along the river bank, a three to five hour trip.

Interestingly, McClain et al. (2001) found a greater use of rivers for transportation purposes in the Peruvian Amazon. In their study, 54.6% of indigenous households and 37.7% of colonist households reported using rivers for transportation. While it is not clear what proportion of total transportation needs were fulfilled by river travel in their study site, it appears that a greater number of households reported traveling by river than in my research communities.

Domestic water supply

As stated previously, most households in San Pedro (15 of 20) have access to running water, which comes from a spring located just outside of town. However, the community members have little money with which to purchase fuel for the water pump. Running water is therefore available only about once per week for half an hour, and sometimes only once every two weeks. Households collect this water in large containers and use it for cooking and drinking throughout the week. Many households reported that the quantity of water that arrives during that half hour period satisfies their weekly household requirement, which is an average of 263.2 liters/week or 37.6 liters/day. Interestingly, this quantity is less than predicted by previous studies of colonist water usage. McClain et al. (2001:403) found that colonist in the Peruvian Amazon reported using 88.7 liters/day/family.

If households need more water than that provided by the pump, they collect it in jugs or buckets from another spring located about ten minutes from town by foot. This spring is also

used for washing clothes by some community members. This is all to say that most households in San Pedro do not use the Acre River as a primary source of water for domestic consumption.

Bathing and washing clothes, on the other hand, are done almost exclusively in the river or at the nearby spring. 81% of households (17 of 21) reported bathing primarily in the river. The remaining households do not bathe in the river because they feel it is too dirty to bathe in, either because of pollution from upstream communities or sediment. They collect rain water, go to the spring, or use their stored potable water for bathing. Sixty-seven percent of households (14 of 21) reported washing clothes in the river. Those households that do not wash clothes in the river wash them at the nearby spring. They also stated that the river was too dirty for washing clothes. Perceptions of water quality will be explored in more detail in Chapter 6.

As in San Pedro, the Acre River does not serve as the primary source of water for domestic consumption for residents of San Miguel. Unlike in San Pedro, however, it is also not used frequently for bathing and washing clothes. This is due to the fact that each house in the community is located next to a small stream, which they use to supply water for their household needs (Figure 4-4). On occasion, families will bathe and swim in the river for recreation, but most use their nearby stream almost exclusively. On average, households reported using 55.6 liters of water per day in the home, which is less than predicted by McClain et al.'s 2001 study. In that study, indigenous households in the Peruvian Amazon reported using an average of 72.7 liters/day/family (McClain et al. 2001:403). When asked why the residents of San Miguel do not use the river more often to fulfill household needs, two households stated that the river is further from the house than the stream is.

Figure 4-4. Each household in San Miguel has access to a small stream that is used for domestic purposes.

Conceptualization of Aquatic Resources

Freelists as an indicator of familiarity with river and riparian resources

As demonstrated by the discussion above, the residents of San Pedro and San Miguel utilize aquatic resources differently. The discussion thus far has focused exclusively on fishing and the use of water as proxies for aquatic resource use. To expand this discussion to the communities' familiarity with other river resources, the results of the freelisting exercise will now be discussed.

As stated previously, freelisting is an anthropological technique designed to elicit a list of items that form a particular cultural domain. For this study, each person (18 men and 17 women in San Pedro, and four men and three women in San Miguel) was asked to list all of the natural resources that are found in rivers, streams and riparian areas. Two conclusions can be reached from the responses. First, the results can indicate whether or not the resources in question actually constitute a cultural domain. In other words, do the interviewees respond similarly to the

question? Second, through an analysis of list length and content, a rough idea of each community's familiarity with and importance placed on river resources can be achieved.

The average length of freelists in San Pedro was 17 items. Men tended to list more items than women, with 23 and 12 items, respectively. This can likely be explained by the fact that most women do not take part in fishing, hunting, or working in the agricultural fields where they would be exposed to species located in water bodies or riparian areas. The 35 respondents listed a total of 264 unique items (Figures 4-5 and 4-6).

The largest category of items was terrestrial animals found in riparian areas (36%). These included game species as well as birds, monkeys, insects and snakes. Also listed frequently were trees found in riparian areas (both timber and non-timber species) (25%) – and fish (16%). Only 6% of the items listed were inorganic substances. These included natural features such as lakes, beaches, rocks, sand, and soil; minerals such as gold, iron, and aluminum; and spirits (listed by only one person).

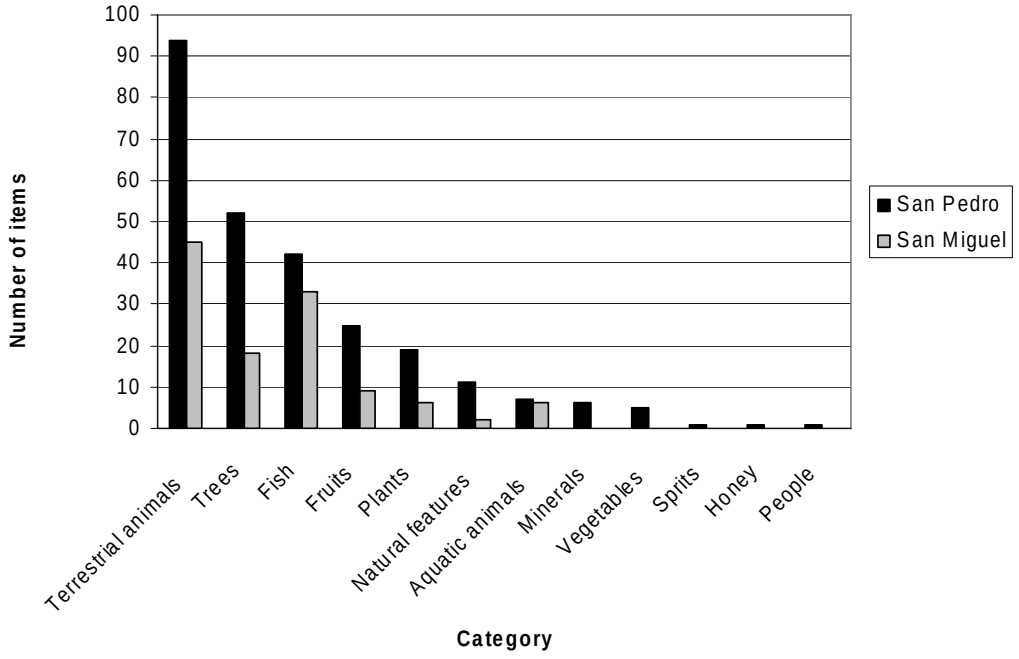

Figure 4-5. Freelisted items (by total number).

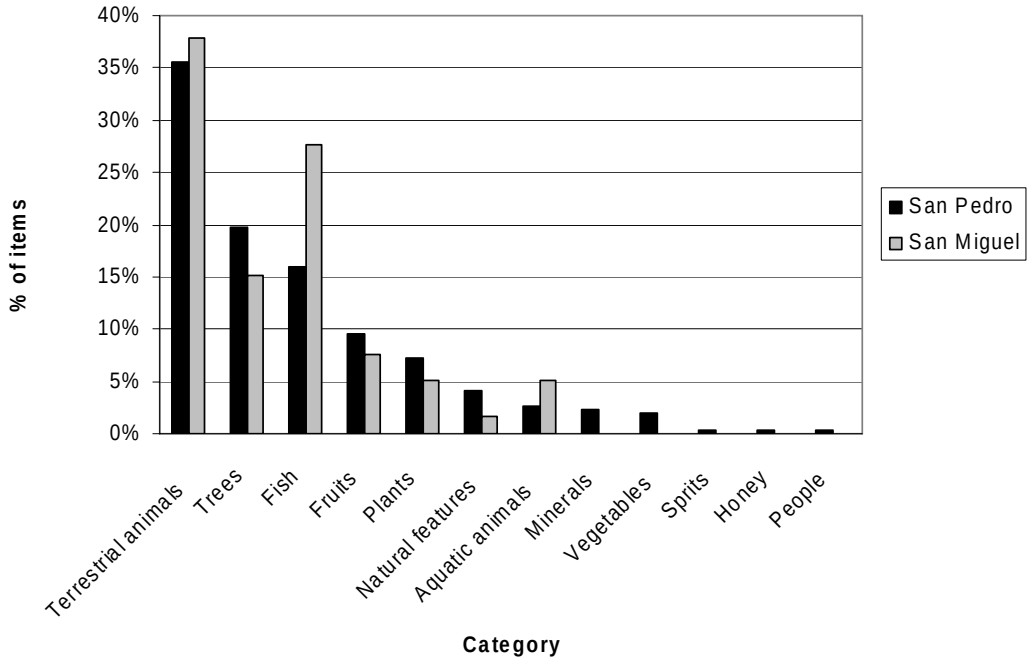

Figure 4-6. Freelisted items (by percent of total).

In San Miguel, the lists were substantially longer, which could reflect that community's stronger dependence on natural resource for their livelihoods. The average list length was 32 items, and 119 unique items were listed by the seven people interviewed (Figures 4-5 and 4-6). As in San Pedro, men listed more items than women (39 and 23, respectively), but the difference between male and female was proportionally smaller in San Miguel. This could reflect the fact that in San Miguel, women are equally involved in almost all livelihood activities with the exception of hunting. It is not uncommon for both the men and women in a household to go fishing or work in the agricultural fields together.

As in San Pedro, terrestrial animals, trees, and fish were the categories into which the majority of items fell, with 38%, 15%, and 28% of the items, respectively. Unlike in San Pedro, however, more fish species than tree species were listed. Furthermore, terrestrial animal species and fish species were listed with almost the same frequency, whereas in San Pedro, terrestrial animals far exceeded the other categories.

The 25 most frequently listed items by all respondents in San Pedro appear in Table 4-1 (each item was listed by at least six respondents).Interestingly, the top three items listed are not species that are consumed frequently. In fact, two of them, *jacaré* and *raya* (caiman and ray) are species from which attacks are feared. *Peta* (turtle) is a highly visible species along the river banks. The following three items listed (*sardina*, *surubí*, and *sabalo*) are species of fish. The remainder of the list is composed of a mixture of game species (6); other fish species (8); snakes (2); and useful tree species like Brazil nut, *asaí* (a species of palm used for its fruit), and *pacay* (a fruit tree) (3).

Table 4-1. Top 25 freelisted items in San Pedro.

	Item	Category	Frequency (# of respondents)	% of respondents
1	Peta	Aquatic animal	17	49
2	Jacaré	Aquatic animal	17	49
3	Raya	Aquatic animal	16	46
4	Sardina	Fish	15	43
5	Surubí	Fish	15	43
6	Sabalo	Fish	12	34
7	Venado	Terrestrial animal	11	31
8	Bagre	Fish	10	29
9	Jochi pintado	Terrestrial animal	9	26
10	Anta	Terrestrial animal	9	26
11	Mono	Terrestrial animal	9	26
12	Cirurí	Snake	8	23
13	Piranambu	Fish	8	23
14	Anguila	Aquatic animal	8	23
15	Castaña	Tree (Brazil nut)	7	20
16	Dorado	Fish	7	20
17	Chancho del monte	Terrestrial animal	7	20
18	Pacu	Fish	7	20
19	Capibara	Terrestrial animal	7	20
20	Piraña	Fish	7	20
21	Vibora	Snake	7	20
22	Pacay	Fruit tree	7	20
23	Palometa	Fish	6	17
24	Asaí	Tree (Palm fruit)	6	17
25	Pescado perro	Fish	6	17

The 24 items listed most frequently by all respondents in San Miguel appear in Table 4-2 (each item was listed by at least three respondents). The most frequently listed item (mandin) is a common species of fish, while the following five equally popular items are a combination of common fish species (2), game animals (2), and one non-game, but "menacing" animal (caiman). The remainder of the list is composed of various fish species (7), game species (6), non-game species (1), other aquatic animals (2), one generic "snake" category, and one tree species.

Table 4-2. Top 24 freelisted items in San Miguel.

	Item	Category	Frequency (# of respondents)	% of respondents
1	Mandin	Fish	7	100
2	Jundia	Fish	6	86
3	Peta	Aquatic animal	6	86
4	Jacaré	Aquatic animal	6	86
5	Jochi Pintado	Game animal	6	86
6	Boca chica	Fish	6	86
7	Bodon	Fish	5	71
8	Cuyú	Fish	5	71
9	Mono silbador	Terrestrial animal	5	71
10	Sardina	Fish	5	71
11	Bacu	Fish	4	57
12	Pava	Terrestrial animal	4	57
13	Mono blanco	Terrestrial animal	4	57
14	Surubí	Fish	4	57
15	Mono maneche	Terrestrial animal	4	57
16	Vibora	Terrestrial animal	4	57
17	Piranambu	Fish	4	57
18	Raya	Aquatic animal	4	57
19	Tatu	Terrestrial animal	3	43
20	Anguila	Aquatic animal	3	43
21	Jochi Colorado	Terrestrial animal	3	43
22	Anta	Terrestrial animal	3	43
23	Denton	Fish	3	43
24	Pacay	Tree (fruit)	3	43

In comparing the lists from both communities, the most striking feature is that they are similar in composition, yet different in specifics. While the most salient elements in the cultural domain of aquatic and riparian resources appear to be fish and game species, the lists overlap on

just over half of the items (27 out of 49). This could indicate that while consensus may exist regarding important aquatic and riparian resources within each community, there may not be a shared cultural domain among all residents of this portion of the watershed. This finding could also reflect the different ways in which these communities use (or choose not to use) river resources.

Using non-metric multidimensional scaling to understand the cognitive domain of river resources

Through a process called non-metric multidimensional scaling, data from freelists can also be used to create a map of the way people cognitively organize items in the cultural domain of aquatic and riparian resources. This analysis was conducted on items that were listed by at least three respondents in San Pedro and by at least two respondents in San Miguel, or by at least five respondents in both communities combined. Multidimensional scaling measures both the frequency with which items are listed *and* how often respondents list the same items together.

The cognitive maps (Figures 4-7 – 4-9) that emerge from this analysis contain useful information. Items that appear close to each other are those that are listed most frequently together, while distance between individual items or groups of items indicates that those items are not frequently listed together. Items that appear near the center of the diagram tend to be those most salient to the cultural domain, while items that appear toward the edges are less salient.

The cognitive map for San Pedro (Figure 4-7) indicates that consensus exists with regard to how people think about aquatic and riparian resources. Many fish species appear together, as do fruits, game animals, and medicinal plants. Interestingly, fruits appear on the opposite side of the diagram from game animals and fish. This is likely because women tended to list fruit species, while men tended to list the other items that are more closely grouped.

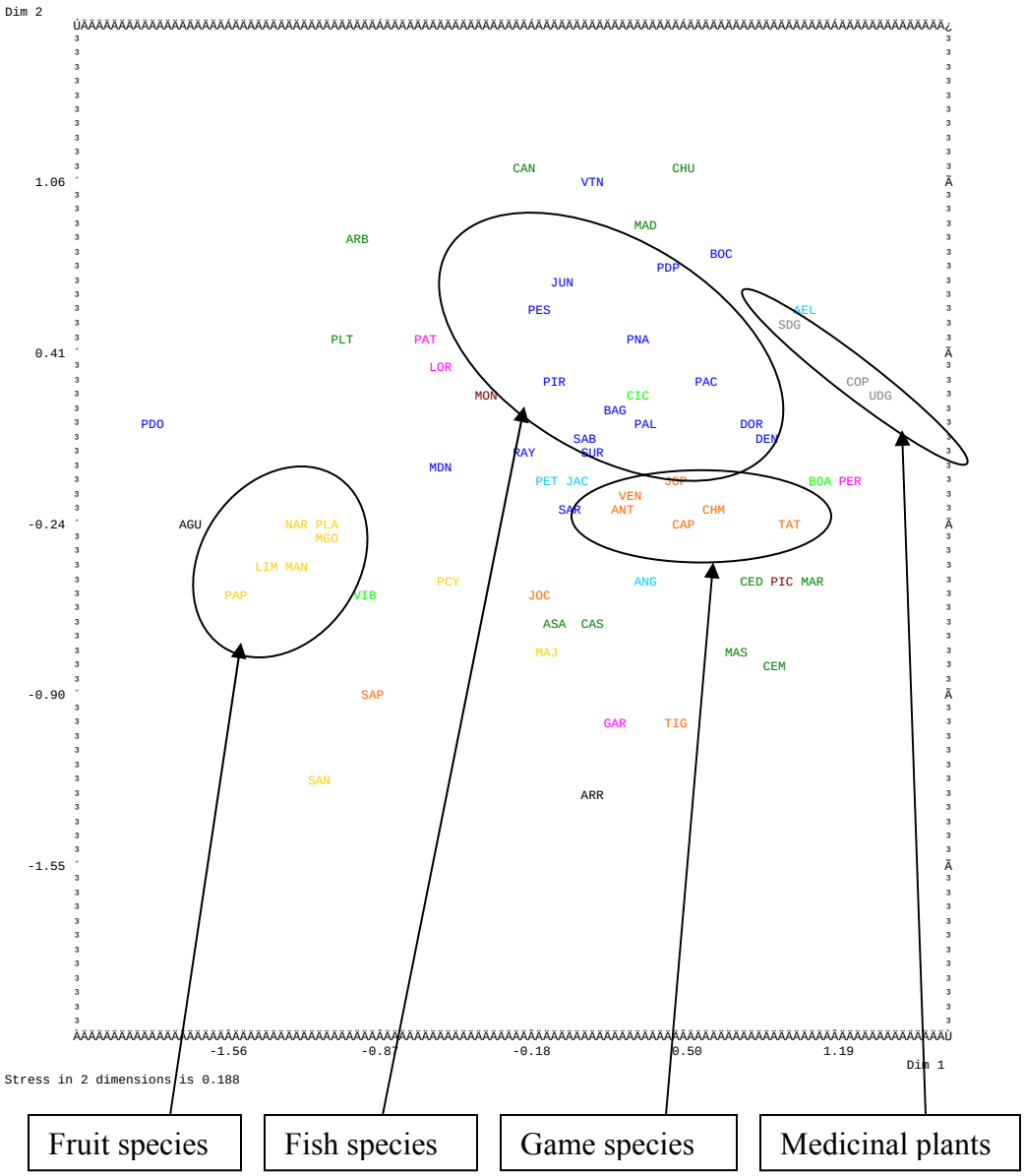

Figure 4-7. Cognitive map of aquatic and riparian resources in San Pedro (see List of Abbreviations). Resources are color coded as follows: dark blue = fish, light blue = other aquatic animals, yellow = fruits, brown = monkeys, dark green = trees/plants, light green = snakes, orange = terrestrial/game species, pink = birds, gray = medicinal plants, black = other.

The cognitive map for San Miguel (Figure 4-8) also indicates cultural consensus. Many of the important fish species appear grouped toward the center of the diagram, while there are also distinct groupings of fruits, monkeys, and tree species. Some game animals appear grouped together, but a number are also spread throughout the diagram. As in San Pedro, gender appears

to influence the map. Fruit trees are located far from timber species, which are listed more frequently by women and men, respectively. However, important fish species, located in the center, were frequently listed by both genders.

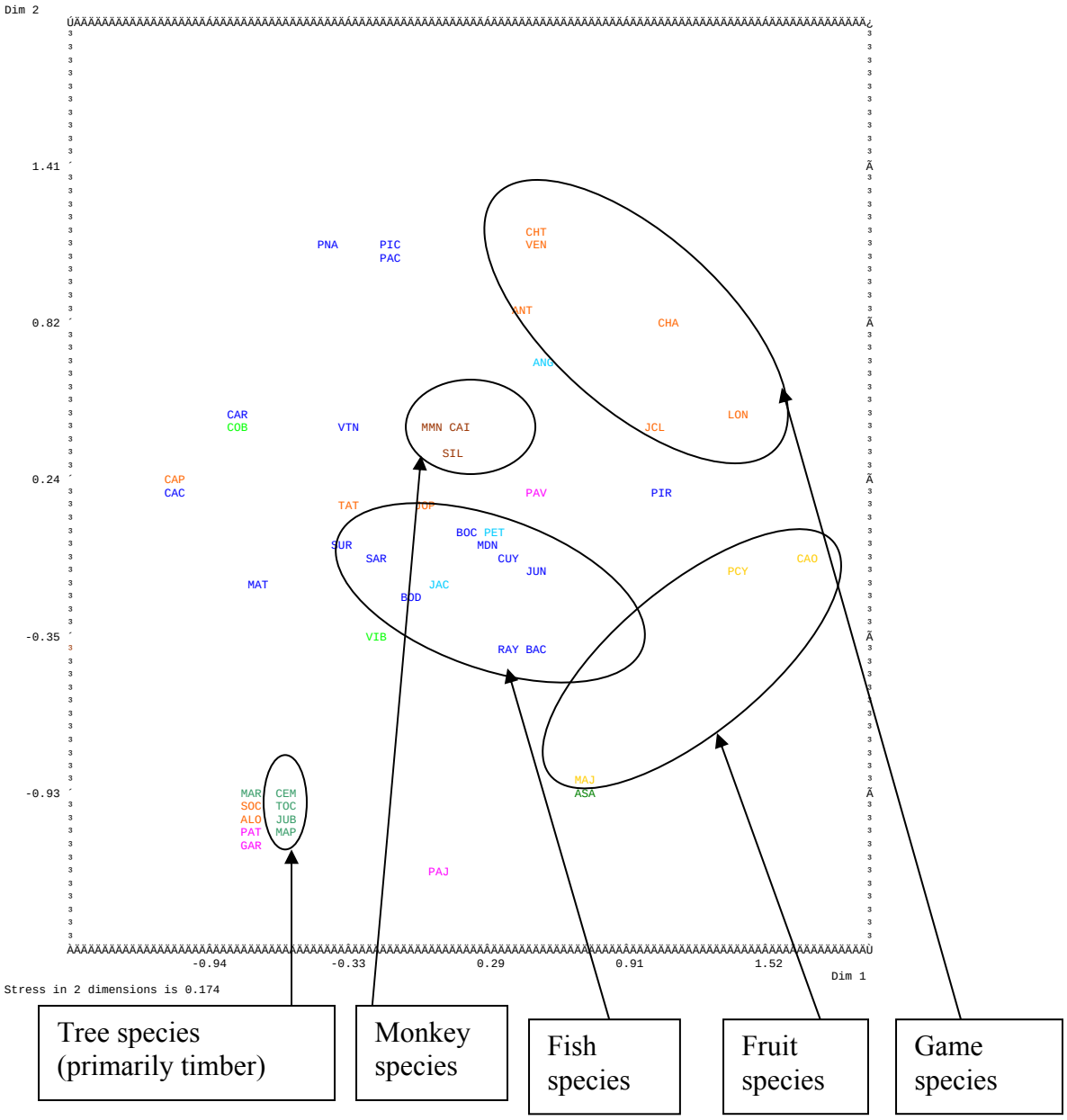

Figure 4-8. Cognitive map of aquatic and riparian resources in San Miguel (see List of Abbreviations). Resources are color coded as follows: dark blue = fish, light blue = other aquatic animals, yellow = fruits, brown = monkeys, dark green = trees/plants, light green = snakes, orange = terrestrial/game species, pink = birds.

When the freelists from the communities are combined, the associations on the cognitive map begin to weaken (Figure 4-9). While distinct groupings of tree species and fruit species are apparent, there is also a substantial amount of scatter among the remaining groups. This scattering mirrors the results of the freelists, in which there was a significant lack of overlap among the most frequently listed items in each community

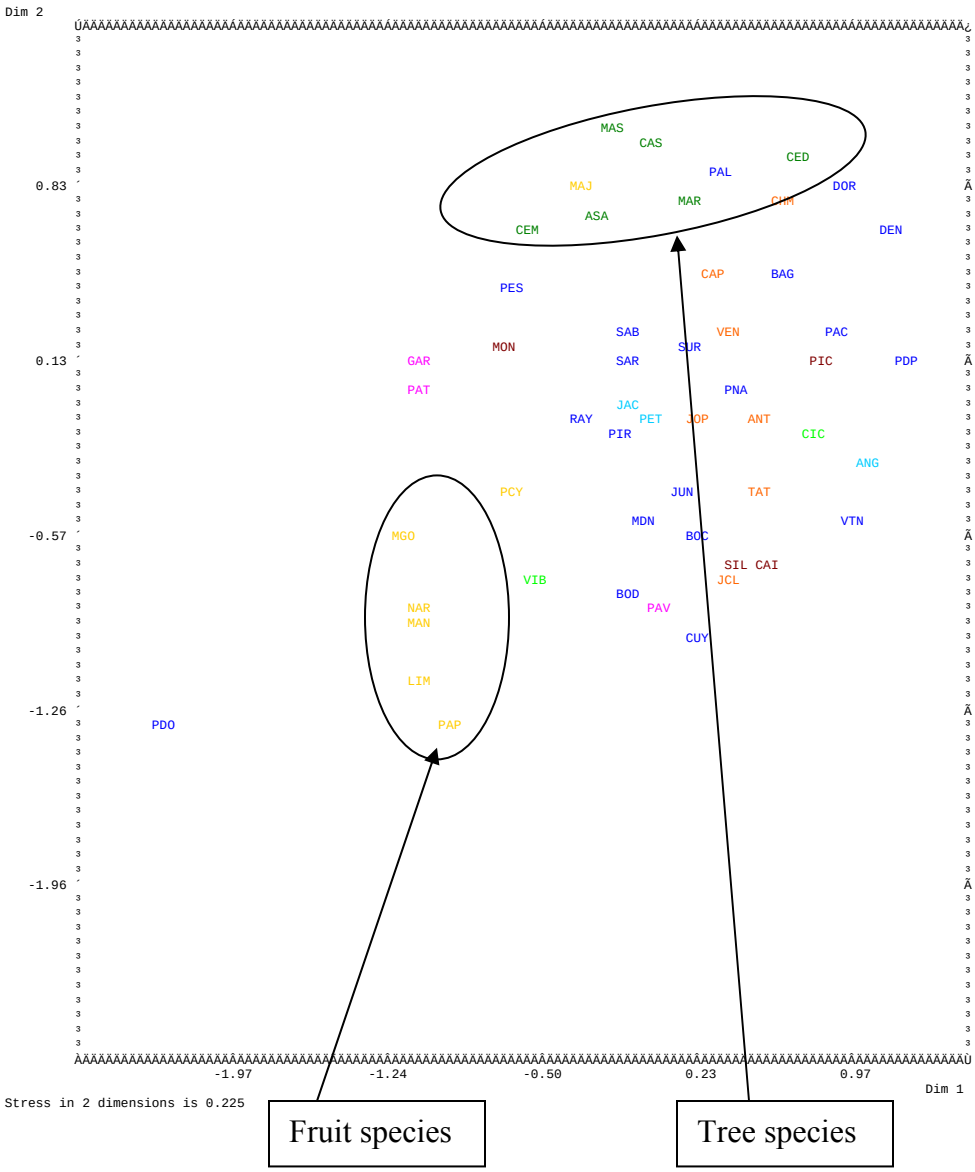

Figure 4-9. Combined cognitive map of aquatic and riparian resources in San Pedro and San Miguel (see List of Abbreviations). Resources are color coded as follows: dark blue = fish, light blue = other aquatic animals, yellow = fruits, brown = monkeys, dark green = trees/plants, light green = snakes, orange = terrestrial/game species, pink = birds.

Conclusion

This section focused on the use and conceptualization of aquatic resources. Figure 4-10 summarizes the use of aquatic resources in each community. The results from the analyses of fishing practices and freelists lead to two important points. First, residents of San Miguel are more familiar with aquatic and riparian resources, and use them to a greater extent in their livelihood strategy than residents in San Pedro. Second, while there is some consensus regarding the constitution of the domain of aquatic and riparian resources, consensus is stronger within each community than between communities. Both of these findings may impact the potential for future collaborative management in that different levels of dependence upon and different ways of conceptualizing these resources are reflective of social heterogeneity in the watershed that may be difficult to overcome. This point will be discussed in greater depth in subsequent chapters.

Table 4-3. Summary of the use of aquatic resources in San Pedro and San Miguel.

	San Pedro	San Miguel
Fishing		
Percentage of households that fish	86%	100%
Frequency	13.7 times/year	2.91 times/week
Total quantity of fish caught per time	2.4 kilos	2.2 kilos (*1.25 kilos according to food log)*
Transportation	2/21 households own canoe (with motor)	1/5 households own canoe (without motor)
Domestic use		
Drinking water source (% of households)	Spring (100%)	Streams (100%)
Location for bathing (% of households)	Primary location: River (81%) Secondary location: Springs	Streams (100%)
Location for laundry (% of households)	Primary location: River (67%) Secondary location: Springs	Streams (100%)

Additionally, while the river acts as a source of transportation and water for domestic use for some households, it is not relied upon to a great extent in either community. However, access to other sources of water is critical to satisfy domestic needs. As will be discussed in the following section, these smaller streams are subject to some degree of protection by many households through the management of riparian areas.

Land Use Practices and Strategies for Water Quality Protection

Communities in riparian areas often benefit from having easy access to water and aquatic resources, but they also have the added benefit of being able to engage in agriculture in relatively fertile riparian areas. In the Peruvian Amazon, McClain and Cossío (2003) documented the intentional use of riparian areas for agriculture and the preferential planting of certain crops in them. They also documented a conscious valuing of riparian areas for the environmental services that they provide. Are these findings consistent with activities in the communities of San Pedro and San Miguel? The following section will discuss the use of riparian areas for agricultural purposes, the preservation of vegetation in riparian zones as a strategy for water quality protection, the reasons why riparian areas are valued by households, and the ways in which households manage garbage and human waste.

Use of Riparian Areas

San Pedro

Of the 18 households that own land in San Pedro, 17 reported having access to at least one stream or to the Acre River on their property. Five households have access to both the river and at least one stream, 11 have access to only a stream, and one household has access to the river but did not know whether they also have access to a stream because the informant does not visit the property frequently. Of the 17 households that have access to a source of surface water on their property, ten households reported clearing agricultural fields near this source, while six

households have not cleared agricultural fields near the water source and one household did not provide this information.[6]

During the household interviews, nine of the 18 land-owning households reported leaving a buffer of vegetation between their agricultural fields and the Acre River or tributary streams when working in riparian areas (three of these households, however, do not currently have agricultural fields in riparian areas so their responses were given in a hypothetical sense). Five households stated that they do not leave a riparian buffer when engaging in agricultural practices near surface water sources and four households are not currently working near a water source and, therefore, did not respond to this question. On average, households reported leaving a buffer of 18.9 meters. This figure includes households that leave no buffers. When households that do not leave buffers are eliminated from the calculation, the mean buffer width increases to 30.7 meters. Reasons given for leaving riparian buffers included

- Providing shade so that the stream does not dry up
- Providing shade so that the water stays cold
- Preventing erosion
- Preserving the quantity of groundwater (that eventually emerges as springs)
- Preserving soil moisture
- Governmental regulations that prohibit the clearing of riparian areas

Reasons given for not leaving riparian buffers included

- Providing access to streams for cattle
- Reducing habitat for poisonous snakes and crocodiles
- "Cleaning" the landscape for aesthetic purposes

[6] In addition to clearing land for agricultural purposes in their individually "owned" lots, some community members also clear fields near town for more frequent use. While some of these fields border the Acre River and other streams, detailed data on the use of these areas and the management of riparian buffer zones are not available.

A common problem in social science research is the fact that people often inaccurately report their own behavior (Bernard 2002). It therefore becomes important to verify information collected in interviews through a process of triangulation. In the case of my research, participatory mapping was a technique that allowed for the gathering of similar data regarding land use strategies but with the added benefit of a visual element to stimulate informant recall. Furthermore, more detailed information regarding field size, locations and types of crops, and protection of riparian buffer zones could be collected while the map was being discussed.

Interestingly, participatory mapping revealed a slightly different system of land use than that which emerged through the household interviews. According to the participatory map of each land-owners property, 11 of the 18 land-holding households left a riparian buffer when creating an agricultural field near the Acre River or a tributary stream, while seven households did not leave a buffer on at least one of their fields. Two of these seven households, however, had left buffers on one of their other fields. When compared with the information provided during the semi-structured interviews, four households mapped larger buffers than they had reported during their interview, four households mapped smaller buffers than they had reported during their interview, and seven households mapped the same size buffers as they had reported during their interview.

The participatory maps also revealed that 22 fields (out of a total of 29) have been cleared within 100 meters of the Acre River or a tributary stream, of which 15, or 68%, have riparian buffers. The remaining seven fields are directly adjacent to the river or a stream on at least one side. When making a calculation using the narrowest width of buffer for each field (many fields have streams on multiple sides or running through their centers), the mean buffer width is 45.6 meters, much wider than that reported during the semi-structured interviews (18.9). This number

is skewed, however, by the presence of three 100 meter buffer zones, which is wide enough to cast doubt on their legitimacy as purposeful buffer zones. When these large buffers are removed from the calculation, the mean width drops to 32.1 meters, or about the same average size as reported during the semi-structured interviews.

A negative correlation, significant at the $\alpha = 0.05$ level (Spearman's $\rho = -0.484$, $p = 0.022$, $n = 22$) exists between the size of agricultural fields and the width of riparian buffer zones (Figure 4-10). As the size of agricultural fields increases, the width of riparian buffer zones decreases. This trend can be explained by analyzing the use of these fields. Smaller fields tend to be used for growing food crops, which, in San Pedro, are generally not irrigated, thus eliminating the need for access to a source of water. Larger fields, however, are used for growing pasture and cattle ranching. Cattle need a source of drinking water; thus, areas along streams or rivers are cleared in order to provide access for the animals.

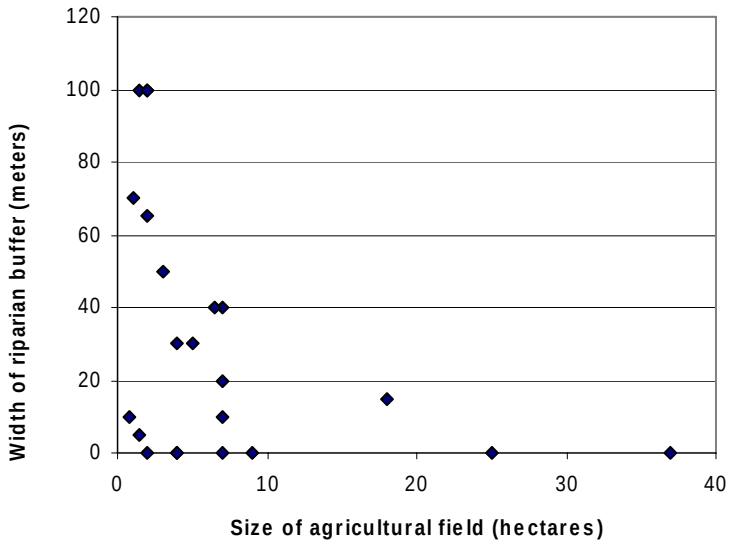

Figure 4-10. Relationship of width of riparian buffer to size of agricultural field in San Pedro.

As stated above, some Amazonian communities preferentially grow certain crops in riparian areas, namely corn, peanuts, and beans, manioc, and plantains (McClain and Cossío

2003). Whether this holds true in San Pedro is difficult to determine because agricultural fields of all types tend to be grouped within close proximity to each other, and many fields (22) are, indeed, located within 100 meters of a surface water source. However, with the exception of delicate vegetables like tomato, cucumber, and peppers that require irrigation and thus must be planted near a water source, and pasture for cattle grazing that also necessitates access to drinking water, the decision about where to plant other staple crops appears to depend more upon the type of soil that is present and the potential for rainfall to accumulate than upon distance from a river or stream. For example, informants stated that rice grows best in low lying areas where rainfall accumulates, while manioc is best grown in sandy soil where there are few remaining tree roots. Corn grows best on higher land where some tree roots remain, peanuts require loose soil, beans require moist soil, and plantains grow best in upland areas with sandy soil. Of course, some individual variation in opinion exists. One informant stated that rice and manioc grow better near a water source because the soil is more fertile from past agricultural activities and because the river or stream keeps the soil moist after it rains. Another informant stated that vegetables grow better along the river banks because of increased soil fertility after flooding. On the whole, however, proximity to a water source does not appear to determine where specific crops will be planted, particularly within fields in which a variety of crops are present. When asked how one learns where to plant their crops, eight households stated that it was through a process of trial and error, two households stated that they learned from older generations, and two households pointed out the lack of technical assistance from the state with regard to helping them learn about the most productive environments in which to plant their crops.

San Miguel

All households in San Miguel have access to land for agricultural purposes. As stated previously, the system of land distribution in San Miguel is less formal than in San Pedro. Households are spread out over a larger area and each household simply chooses a location near their house in which to create their agricultural field or fields.

Four of the five households reported clearing agricultural fields near the Acre River or a tributary stream. The fifth informant stated that he intentionally creates fields away from surface water bodies, but then stated that a minimum distance of 10-20 meters from a water body was acceptable. All households reported leaving riparian buffer zones when working near bodies of water. On average, households reported a mean riparian buffer width of 32.5 meters. Reasons given for leaving riparian buffers included

- Preserving water quantity in the stream or river
- Preventing crop loss from flooding when the water rises
- Preventing ashes from burned fields from contaminating sources of drinking water
- Providing shade so that the stream does not dry up

There were no reasons given for not leaving riparian buffer zones.

As in San Pedro, participatory mapping revealed both more detailed and slightly different information regarding land use patterns. Eleven fields (out of a total of 14) had been cleared within 100 meters of the Acre River or a tributary stream. Of these 11 fields, a riparian buffer existed along ten of them (90.9%). Again, using the narrowest width of buffer zone for each field to make the calculation, the mean width of riparian buffers was 26.7 meters. If one 100 meter-wide buffer zone is eliminated from this calculation, the mean buffer width drops to 18.5 meters. It appears, therefore, that while a greater percentage of fields near the river or streams are separated from these water bodies by riparian buffers in San Miguel than in San Pedro, the

buffers themselves are actually narrower, a finding that mirrors the pattern encountered by McClain and Cossío (2003) in the Peruvian Amazon.

There is no statistical correlation (Spearman's $\rho = 0.121$, $p = 0.724$, $n=11$) between the size of agricultural fields and the width of riparian buffers in San Miguel (Figure 4-11). However, there is also much less variation with regard to the size of agricultural fields and the width of riparian buffers in San Miguel than there is in San Pedro. This may partially explain the apparent lack of correlation between these elements. Furthermore, no households in San Miguel currently raise cattle, thus eliminating the need for large fields with no riparian buffers near streams.

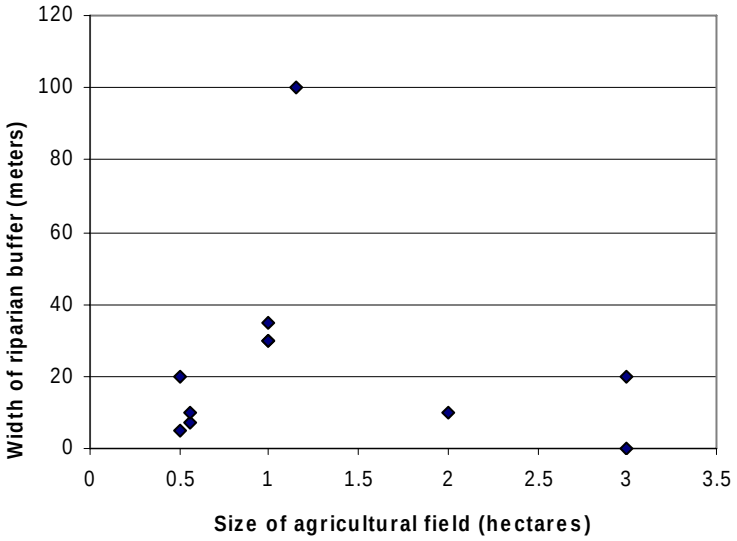

Figure 4-11. Relationship of width of riparian buffer to size of agricultural field in San Miguel.

Agricultural practices in San Miguel are similar to those in San Pedro in that there appears to be little preferential use of riparian areas for the planting of specific crops. When asked where their crops were planted, informants responded by describing soil characteristics, much as they did in San Pedro, rather than by referring to proximity to landscape features like rivers and streams. According to responses given during the household interviews, manioc and beans are best grown in sandy soils, manioc grows best in areas where there is no flooding and few tree

roots, and rice grows best in areas without sandy soil. No households mentioned the proximity of a water source as a characteristic necessary for agricultural production, despite the fact that most fields were located within 35 meters of a river or stream. Only one household planted crops (watermelon) on land directly adjacent to the Acre River, but this was substantially downstream from the community and was not included in the calculations above. When asked how one learns where to plant their crops, two households stated that it was through a process of trial and error, one household stated that they always clear fields in upland areas because the soil is better there, and two household stated that they learned about the best locations for crops from experience.

Value of Riparian Areas

As discussed above, a majority of households in both San Pedro and San Miguel leave at least a minimal forested buffer along the river and streams when clearing agricultural land. However, regardless of whether or not people actually leave riparian buffers, they may place importance on the ecological functions of riparian areas. In this spirit, households in both communities were asked whether they thought riparian areas were important and, if so, why.

In both communities, all households responded affirmatively to this question. Figure 4-12 summarizes the results. In San Pedro, the most salient ecological functions of riparian areas had to do with preventing erosion and maintaining the width and depth of the river channel. In San Miguel, on the other hand, households placed importance on tree species that grow in riparian areas and provide food for human consumption like asaí, majo, mandarins, oranges, pacay and papaya. This finding makes sense given households' greater dependence on natural resources for daily survival. However, households in San Miguel also valued riparian areas for their role in preventing soil erosion.

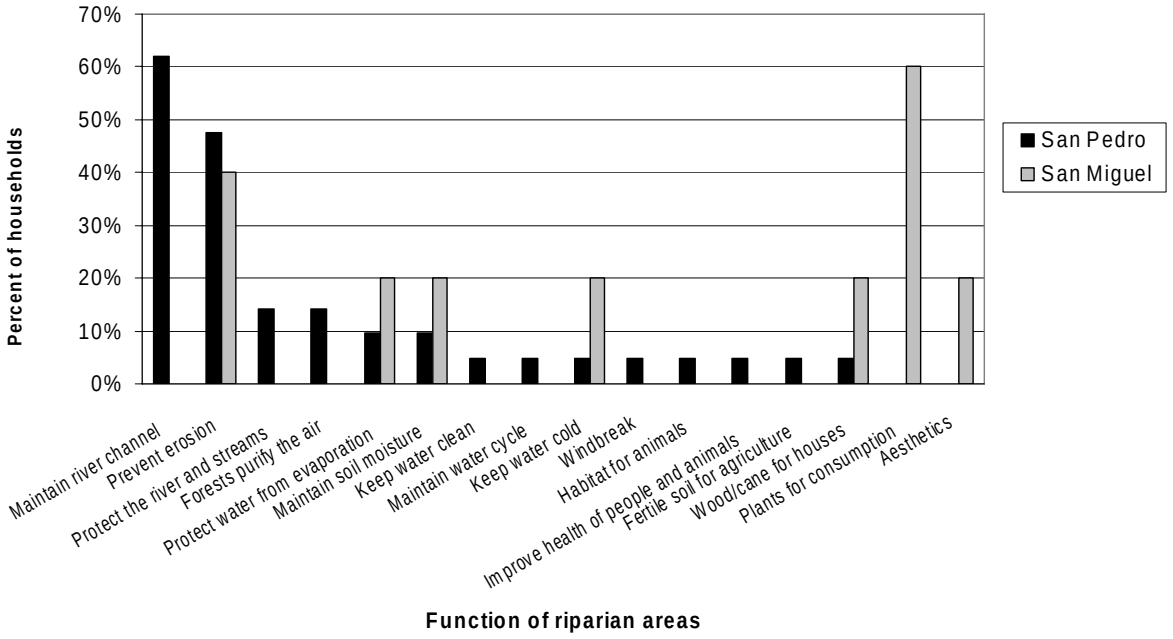

Figure 4-12. Perceptions of riparian area function.

The origin of these value systems was not entirely clear. In both communities, various informants referred to *técnicos* (agronomists from the Ministry of the Environment, the Universidad Amazónica de Pando, or the Fundación José Manuel Pando) who visited the communities to provide workshops on the protection of riparian areas. Some residents in San Pedro were aware of governmental regulations that prohibited the clearing of riparian areas within 100 meters of the Acre River.

Personal history, however, also played a role. Many informants had witnessed problems with erosion in riparian areas along the Acre River, and the drying of streams and springs on their lands. In San Miguel, some informants stated that the protection of riparian areas was "Machineri custom."

Water Quality Protection Strategies

In addition to agricultural practices, systems for dealing with human waste and garbage disposal in riparian areas can also impact water quality. The question, then, is whether the

communities of San Pedro and San Miguel intentionally protect water quality by encouraging or restricting certain activities.

Fourteen households in San Pedro have a personal outhouse. The remaining households share a public toilet. All toilets in San Pedro are latrines. When the latrine is full, the household simply covers it and digs a new pit. Though major floods have reached the latrines at times, this is not a frequent occurrence. Latrines for houses at the port (directly across the river from Assis Brasil) are located an average of 47 meters inland. For houses located closer to the town center, the average distance from latrines to the river is 189 meters.

The community does not have an organized system for disposing of household garbage. Each household collects its own waste, burns what it can, and buries the rest. All households reported refraining from dumping garbage into the river, and many expressed negativity toward upstream communities who do so.

Households in San Miguel do not have latrines. The location to be used as a bathroom is selected by each family. On average, bathroom sites are located 477 meters inland from the Acre River. The school in San Miguel does have a latrine, which is located 53 meters from the river. Households reported that their toilets do not flood when the streams near their houses rise. However, at least one household that I observed had located their bathroom area just uphill from a small stream that was used for drinking water, bathing and washing clothes by a downstream household. Human waste likely runs into the stream during rainstorms.

As in San Pedro, household garbage in San Miguel is burned or buried. While garbage was not disposed of in the Acre River, the banks of the stream used by two households were somewhat littered with household waste.

Conclusion

In the end, it is clear that land use practices in riparian areas differ between these communities. Figure 4-14 summarizes the use of riparian areas in each community and provides a comparison of data collected from interviews and data collected through participatory mapping.

Table 4-4. Summary of the use of riparian areas in San Pedro and San Miguel. Note the differences in data collected through interviews and data collected through participatory mapping.

	San Pedro	San Miguel
Number of households that have agricultural fields near riparian areas (% of households)	10/17 households (59%)	4/5 households (80%)
Number of households that leave riparian buffer when creating agricultural fields in riparian areas (% of households)	9/18 households (50%)	5/5 households (100%)
Average reported buffer	18.9 meters	32.5 meters
Data from participatory mapping: Number of households that leave riparian buffer when creating agricultural fields in riparian areas (% of households)	11/18 households (61%)	4/5 households (80%)
Proportion of individual fields with a riparian buffer (% of fields)	15/22 (68%)	10/11 (91%)
Average mapped buffer	45.6 meters	26.7 meters

While households in both communities located some agricultural fields near surface water bodies, only about half of the households in San Pedro reported preserving a buffer of vegetation between their field and the nearest water body. Households in San Miguel, on the other hand, all reported leaving such a buffer, though participatory mapping revealed that this was usually, but not always, true. Interestingly, while more households in San Miguel preserved riparian buffer zones, the average width of these zones was narrower. And, while individual households in each community may possess knowledge or an ethic that leads them to protect these areas, this

management system is not formalized in either community. This idea will be discussed in greater depth in the following chapter.

One interesting point of similarity between these communities, and one that stands in contrast to previous findings (McClain and Cossío 2003) is that households do not appear to consider proximity to a water source when making decisions about where to plant their crops. However, it does appear that, more often than not, agricultural fields are created within 100 meters of a river or stream. Whether this location is due to soil characteristics or to issues relating to personal comfort (e.g., providing a nearby source of drinking water when farming) was not determined.

Riparian areas are valued for different reasons in each community, In San Pedro, the general perception is that riparian areas serve a clear ecological purpose – that of preventing erosion, maintaining the depth of the river channel. In San Miguel, on the other hand, ecological function was secondary to the material goods provided by these areas.

Finally, the communities were similar in their approach to dealing with household waste in that neither community regularly used surface water bodies or riparian areas as a location for garbage disposal. And, while their systems for dealing with human waste were different, neither of them involved preferentially siting toilets near water bodies.

CHAPTER 5
NATURAL RESOURCE GOVERNANCE

Thus far, this discussion has addressed natural resource use at the individual or household level. Decisions about resource management, however, often extend beyond the boundaries of the home. This is particularly relevant to water because it flows through ecosystems and communities and is thus a necessarily shared resource. It is, therefore, not uncommon for cooperative management systems to emerge around water resources (see Acheson 1987; Adger and Luttrell 2000; Berkes 1987; McGrath et al. 1993; Olsson and Folke 2001; Stocks 1987; Taylor 1987; White and Runge 1994). These systems can involve both water resources with natural boundaries, such as lakes, and more broadly shared marine and river systems. Is this the case for the communities on the Acre River? Have inter- or intra-community management systems been developed in order to govern access to and use of aquatic and riparian resources?

Ostrom (1990) has outlined the principles that make common property resource systems successful. These include an ownership arrangement with management rules, clearly defined physical boundaries, sanctions to ensure compliance, and conflict-resolution mechanisms. The following sections will discuss the presence or absence of these features within the communities of San Pedro and San Miguel. It will also discuss communication between neighboring communities with regard to natural resource management, and how perceptions of upstream-downstream connections influence decision-making at the household level.

Intra-Community Management Systems

San Pedro

Management rules

In order to promote a discussion of both formal and informal management systems, my interview employed a hierarchy of increasingly weaker types of agreements. The inquiry began

with questions about the existence of formal limits on resource use and the existence of a person (or group of people) that enforces those limits, proceeded to a review of informal agreements, and finally on to whether casual discussions about resource use occur. In addition, the context in which each of these discussions take place, if they do, was explored.

The community of San Pedro does not appear to have a formalized system for managing access to aquatic resources. When asked whether limits on the use of aquatic resources exist within the community, including limits on the quantity of items that could be harvested at once or the timing of resource use, 12 households responded that there were no such limits, three households responded that limits did exist, and six households did not know whether limits existed. However, of the three households that responded that limits existed, one identified the limits as originating from external sources including an international law that governed fishing during the spawning season, national regulations that define the width of riparian buffer that should be left on river banks, and restrictions to fishing during spawning season that are enforced by Brazil's environmental enforcement agency, the Instituto Brasileiro do Meio Ambiente (IBAMA). Another household referenced laws implemented by the Bolivian National Agrarian Reform Institute (INRA) that delimit community boundaries, while the third household claimed that limits to resource use were self-imposed by each person in order to protect the populations of those resources. No household, then, referred to any local rules governing resource use when asked this question. In fact, a number of households stated that there was no need for rules to govern resource use because households in San Pedro do not exploit natural resources to a great extent and do not rely on fishing for survival. Furthermore, the resources that they do use are limited to quantities appropriate for personal consumption. Interestingly, two households stated that Brazilian fishermen and hunters represent a more serious threat to natural resources because

they fish and hunt for commercial purposes and without regard to the population sizes of those resources. These households felt that there was little they could do to limit the exploitation of aquatic resources by Brazilians because the river is equally shared by the two countries. As one informant stated

> The Brazilians [fish] frequently and no one can say anything because half the river is theirs and half is ours. And you can't say anything. I don't know how much, but they take a lot of fish. Big fish. It takes three people to lift them.

Another informant expressed a feeling of powerlessness with regard to illegal hunting

> . . . mostly it is Brazilians that come here to hunt and it is them that exploit. We still don't have laws that prohibit those things. And we, as civil citizens, can't say anything to the Brazilians. They're vengeful, the Brazilians, they're mean. For that reason, we don't get involved. We don't want problems with anyone.

Whether or not communities have formal rules governing resource use, there may be a sense that an individual or group of individuals is managing access to natural resources in a *de facto* sense. When asked whether there was someone who controlled access to riparian and aquatic resources, 14 households stated that such a person did not exist, while seven households stated that someone did, in fact, control access to these resources. Much like in the previous responses, however, emphasis was placed on the role of external actors in resource management rather than on intra-community agreements. Governing authorities included national governmental agencies, such as the Ministry of the Environment or the Forestry Superintendent; Bolivian military staff from the small military outpost located near the town; or Brazilian authorities, such as IBAMA or the Brazilian military. According to these informants, agency or military staff occasionally conducted river patrols, but not with enough frequency to effectively control resource exploitation. Only one household stated that the community itself controlled access to resources, but it did not identify a single individual or group within the community that held management authority.

In addition to a lack of formal rules regarding resource use, San Pedro also lacks widely accepted informal rules. When asked whether informal agreements regarding the use or protection of aquatic resources existed within the community, 19 households stated that such agreements did not exist. Only two households stated that there were such agreements. Of these two households, one household felt that the community members understood and abided by rules created at the level of the municipality, including prohibitions on the disposal of household garbage and sewage in the river. This understanding was enhanced by conservation-oriented trainings that have been conducted by non-governmental organizations in the community. The second household stated that informal agreements sometimes arose in the context of community meetings

> There are talks . . . Within the community. There are times when there is a meeting and for a point of discussion someone says that in the time of making the *chacos* [agricultural fields], we shouldn't clear close to the shore. We have a goal of reforesting here because the river is eating the land up.

Two other households stated that informal discussions occasionally occurred among community members regarding resource use. One of these households highlighted discussions that take place regarding restricting deforestation near small streams so that water levels are maintained within the streams. The second household, on the other hand, commented on the ineffectiveness of discussions about community-initiated resource management because of the resource exploitation that takes place by people from outside the community

> Those kinds of talks exist, about not destroying, but they don't function because our neighbors are those that cause the destruction of aquatic resources. What good does it do us, as Bolivians, to claim to protect but the neighbors don't? . . . The problem is that there are people that enter and destroy.

Riparian areas, similar to aquatic resources, also lack a formal management system. Nineteen households stated that there were no agreements regarding the use and protection of riparian areas within the community, while two households stated that there were such

agreements. However, each of these two households commented that while some community members discuss the protection of riparian areas, not everyone is of the same mindset and some community members continue to deforest these areas when clearing land for agricultural purposes. One respondent expressed the concern that agreements limiting the ways in which people can use their land might have a negative impact on individual rights

> The people that work in the field see the areas near streams as better and they make a house or put an animal there. If those laws are against that, the campesino will be affected. One part is the protection of the environment, the other is the rights of the campesino.

Another respondent felt that there were not formal agreements, but did comment on discussions that take place when dealing with specific issues in riparian areas that affect the community as a whole

> . . . self-control exists. Many times, there is a stream or a source of water that supplies various families. That small pond that we were making [for the potable water]? Someone wanted to put an agricultural field there. In a meeting, we had to determine that he should not touch that part. Even though it was part of his property, the community was going to benefit from that pond so they stopped [the land clearing].

Ultimately, most households in San Pedro were in agreement that there are no formal rules or informal agreements that govern the use and protection of aquatic or riparian resources. This seems to be partially because community members look to governmental bodies for rules regarding resource use. A common theme that arose during these discussions was that of the existence of rules and regulations for resource use and protection created by external actors, including national, departmental, and municipal governments. In addition, a lack of enforcement was a concern given that officials from rule-making bodies did not visit the community due to its distance from urban centers. In addition to affecting resource management, this pattern also exacerbates the sense of isolation felt by the community of San Pedro.

Physical boundaries

Although this topic was not included in the semi-structured interviews, personal observation indicates that physical boundaries that define the ownership of the river, either by individuals or by the community as a whole, do not exist. Boundaries defining riparian areas exist only to the extent that these areas fall within the agricultural lots used by community members.

Sanctions

The lack of formal rules for aquatic and riparian resources precludes the development of locally enforced sanctions for unsustainable uses. Continuing with the theme of dependence on external actors for rules about resource management, three households stated that sanctions could be imposed by institutions from outside of the community, such as the forest and wildlife superintendencies. These institutions, however, only govern only terrestrial resources. In addition, because of the geographic isolation of the community, representatives from these institutions do not visit frequently enough to adequately enforce national laws.

No households identified any community-created sanctions for households or individuals that violate informal resource management agreements. One informant stated that the small size of the population made such rules unnecessary, but was also concerned that with future population growth, such sanctions might become necessary. Another household felt that social pressure made sanctions untenable

> There aren't any sanctions. Here [referring to an agricultural field located directly adjacent to the river, without a riparian buffer zone], nobody said anything. And they get annoyed with the person who wants to take actions [against the landholder].

Conflict Resolution Mechanisms

As stated above, the final component to a common property management system is a mechanism for the resolution of conflicts stemming from unacceptable resource use. As a first

step in determining whether this mechanism exists in San Pedro, I was curious about what types of conflicts are most common within the community. If conflicts stemming from aquatic or riparian resource use are uncommon, there would be little need for the community to develop a conflict resolution mechanism for these issues.

The most common type of intra-community conflict reported by households was that between individuals (n=7). This type of conflict stemmed from personality conflicts or small misunderstandings. In second and third places (n=5 and n=4, respectively) were conflicts stemming from families looking out for their own social and economic interests rather than performing tasks for the good of the community, and from a general sense that factions within the community cause it to function without unity. These factions ran along various lines, including family, religion, and profession. Other sources of conflict included a lack of participation by some in community projects, a lack of understanding due to cultural difference between households from different regions of Bolivia, envy, corruption on the part of elected officials, a lack of infrastructural development within the community over the long term, the out-migration of established households, and a failure on the part of individuals to contribute financially to the fulfillment of community needs, such as gas for the community water pump and repairs for the community-owned rice husker.

During my field work, I observed two additional and ongoing conflicts. The first of these revolved around the fact that prior to my arrival, the state government had provided funds for the construction of six new houses in San Pedro that were intended to be given to families whose main income was generated through agriculture. The actual allocation of these houses to families, however, was not a transparent process and a number of families felt that they had been unjustly denied a new home due to being out of favor with the community authorities. Suspicion

also arose from the fact that family members of the municipal mayor (a resident of San Pedro) were given two of the six available houses when others felt that there were equally, or more, needy families.

The second ongoing conflict observed was over land "owned" (recall that no households hold individual land titles) by households whose members had left the community on a semi-permanent basis. According to Bolivia's agrarian reform law, if land is not put to productive use for a period of three months, it can be reclaimed by the community and redistributed to landless families. During my fieldwork, this issue arose with a household whose elderly patriarch had left the community, but whose land was being farmed by his middle-aged son because it was located closer to the urban center than the son's lot was. Various community members objected to this informal transfer of use rights and wanted to reclaim the father's land for redistribution. Over the course of my fieldwork, this issue arose at various community meetings; each time, reclamation was successfully resisted by the son. This resistance did not, however, prevent the issue from arising again because lots close to the urban center are highly valued and thus watched carefully. According to the community members, this was not the first time that struggles over access to land had arisen in the community. In the community's relatively short history, transfers of lot ownership had occurred a number of times. Interestingly, the conflict surrounding the new houses was only identified by two households as a source of conflict while the issue surrounding access to land was not reported by any households as a source of conflict. This was surprising given that these issues were frequent topics of both casual conversation and community meetings.

When asked how intra-community conflicts are resolved, most households stated that they are resolved in community meetings or through individual interactions. In my estimation, the

mayor occasionally played a role in resolving conflicts, though it was not clear whether this was his duty as mayor, despite the fact that his mayoral position was at the level of the municipality and thus gave him limited local authority, or whether he took on the responsibility as an individual and authoritative member of the community. No formalized process for resolving conflict within the community was revealed during the interviews.

Only two households identified natural resource use as a point of conflict. The problems, they claimed, stem from Brazilians and Peruvians illegally entering the community's territory to hunt and log. As has been discussed previously, the community feels somewhat powerless to stop the invaders. However, no intra-community conflicts over the use of aquatic or riparian resources were identified. There has, therefore, been little need to establish a formal conflict resolution mechanism to deal with this type of problem.

In conclusion, San Pedro lacks each of the four elements that characterize common property management systems: management rules, clear physical boundaries, sanctions in case of rule violations, and a clear conflict resolution mechanism. One can only conclude, therefore, that aquatic and riparian areas near the community are treated as open access resources, or in some cases as private resources if the areas fall within the lots managed by individual households.

San Miguel

Management rules

As in San Pedro, the community of San Miguel has not created management rules for the use of aquatic resources. Four households stated that use of aquatic and riparian resources is not limited by the community, while one household did not know whether limits to the use of aquatic and riparian resources existed. Every household stated that the use of both aquatic and riparian resources was determined individually based on subsistence needs. As one household stated

Household #3: We don't fish to catch a lot. Just a little, so we can eat for a day.

Interviewer: So a limit isn't necessary because you don't catch much?

HH3: Yes.

While some households based their harvest decisions only on the needs of the household, one household paired its subsistence needs with an awareness of the reproductive needs of fish populations

Household #4: You can't catch a lot because sometimes they [go extinct].

Interviewer: So it's a personal limit for you. You say I'm only going to catch what I need to protect the fish so that there are always fish there?

HH4: Yes.

I: But there isn't a limit that is imposed by another person in the community?

HH4: There isn't one here.

Unlike in San Pedro, there was little discussion of the responsibility of outside actors in resource management and the enforcement of management rules. This can perhaps be attributed to the greater physical isolation of San Miguel, which creates a barrier both to information flow about national resource laws and to the physical presence of agency officials. In addition, the language barrier that exists in San Miguel, where most adults speak only Portuguese, creates additional difficulty for Bolivian officials. Regardless of the reason, the fact remains that the residents of San Miguel did not expect external actors to assume the responsibility for resource management to the same extent as did those of San Pedro.

When asked whether a *de facto* manager of access to aquatic and riparian resources existed, despite the absence of formally established limits to resource use, all households responded in the negative. In addition, no informal agreements about aquatic and riparian resource use or water protection exist in the community. One household, however, stated that a talk on the protection of riparian areas was given by an outside group the previous month.

Though the informant could not recall who was responsible, it was likely that it was the Fundación Jose Manuel Pando, one of the environmental NGOs based in Cobija that works on forest issues in Pando. In addition, my field assistant informed me that previous trainings had also been provided by the RIPUI (Relevamiento de Información Sobre Potencialidades y Usos Integrales) project, a collaborative effort between the Universidad Amazónica de Pando and the Field Museum in Chicago. So, while agreements may not exist, the community does have some knowledge of riparian area protection.

While widely practiced management agreements have not been established, one informant commented that informal discussions about protecting aquatic resources have occurred among individual community members. This informant recalled having discussions with three other households in the community about not trying to catch too many fish

> **Household #4**: Sometimes, people talk that it isn't good to take a lot. You have to take a little.
>
> **Interviewer**: Who participates in those conversations? Are they informal conversations or during community meetings?
>
> **HH4**: Informal.
>
> **I**: Who have you talked to about those things?
>
> **HH4**: [Households 1, 2 and 5]

Interestingly, though perhaps not surprisingly, given the greater dependence of households in San Miguel on terrestrial resources than on aquatic resources for subsistence, more households recalled having discussions regarding the protection of riparian resources. These conversations appear to have occurred in the context of workshops and during informal conversations both between and within households. These conversations appear to have resulted in an ethic of riparian area protection, as four households claimed that everyone was aware that riparian areas should remain forested when clearing land for agricultural fields. Though there is no consensus

on the width of forest that should be left standing in riparian areas, all households were in agreement that the protection of riparian areas was a common practice. The accuracy of this attitude is supported by the land use practices discussed in the previous chapter.

Physical boundaries

As in San Pedro, personal observation indicates that physical boundaries defining the ownership of a section of river or riparian zone do not exist. The community has a clearly defined terrestrial boundary on one side, as it is directly adjacent to the boundary of the TCO. However, this boundary does not seem to influence natural resource management decisions. Households do not tend to farm land that is directly adjacent to the river, thus there is no informal ownership of riparian land in the same way that there is in San Pedro, where many lots are bounded on one side by the Acre River.

Sanctions

As in San Pedro, internal sanctions for unsustainable resource use have not been developed, likely due to the fact that formalized rules for resource management do not exist. Unlike in San Pedro, however, households in San Miguel made no reference to the role of external actors in enforcing national laws. Again, this is likely explained by the greater social, cultural and physical isolation of the community from mainstream Bolivia.

Interestingly, the homogeneity of the community is reflected in the response of one household to the question of what a potential sanction might be if someone violated a resource management agreement that had been created by the community

Household #5: Everyone is in agreement here

Interviewer: But the question is, if everyone wasn't in agreement, what would happen?

HH5: Everyone is in agreement. That has never happened.

Conflict Resolution Mechanisms

As stated previously, the community of San Miguel has a small population and is strongly connected through a series of kin relations. There is therefore little readily observable conflict and little need to develop a complicated structure for organizing activities within the community. As elaborated in the Bolivian Popular Participation Law, San Miguel does have a governing body, with an elected president, vice president, and secretary/treasurer. It is not terribly active, however, and the elected representatives seem to defer to the *de facto* leader of the community, who is a member of one of the founding households, for representation in local and regional meetings.

When asked directly about the greatest source of conflict in the community, only one household reported the existence of any conflict, and that response was limited to some dissatisfaction with the capacity of the elected president to coordinate activities within the community and with an unequal work ethic among members of the community, which made cooperative agricultural work problematic. All other households responded that conflicts did not exist within the community.

Given the lack of a strong governing body and a minimum level of conflict, no formalized strategy for conflict resolution was identified by the residents of San Miguel. Rather, when conflicts arise, they are resolved by simply talking to each other in informal settings and during community meetings. For example, in addressing concerns about the contamination of a local water source by one household, the following strategy was presented

> **Interviewer**: Are there sanctions if someone breaks the rules? Do you talk to a person who, for example, deforests everything?
>
> **Household #4**: I think so because there is a lot of illness. Don Martin, all have to protect the water, not throw garbage. We told him that it's not good to throw garbage [because it contaminates the water for Don Manuel.]

I: What happens if he continues?

HH4: We could get sick from the water.

I: What would you say to him?

HH4: We just talk about it [not in a meeting]. And he says he'll control his family.

I: So you resolve those problems through talking among the community members. If there's a problem, you talk and everything's ok?

HH4: Yes.

Ultimately, as in San Pedro, San Miguel lacks formalized resource management rules, clear physical boundaries for the waterways in question, a system of sanctions for rule violations, and a formalized conflict resolution mechanism. It must be concluded, therefore, that the water bodies surrounding the community are managed as open access resources and are not subject to a common property resource management system.

The lack of a management system for aquatic and riparian resources in both communities has much do with the lack of dependence on these systems for subsistence. There is little motivation to manage natural resources that are not critical to daily life. However, an additional explanatory factor could be that, cognitively, the problems with water quality that are of concern to these communities have very little to do with activities occurring in riparian areas. This idea will be expanded upon in the following chapter.

Inter-Community Management Systems

As just discussed, the communities of San Pedro and San Miguel do not treat aquatic and riparian resources as common property resources and therefore have not developed a formalized system for managing their use. However, informal resource management discussions have occurred within each community, and it is possible that similar discussions have occurred at a broader scale among the communities located along the Rio Acre. To this end, households in

each community were asked about communication that has occurred with other communities located both upstream and downstream.

In general, relationships between the communities along this short stretch of the Acre River appear to be good, if somewhat superficial. In San Pedro, most households characterized the community's relationship with Iñapari and Assis Brasil as beneficial to the community in that they communicate with each other about the provision of health services and educational campaigns. Additionally, they each participate in each other's community celebrations and soccer tournaments. Some concern was expressed about San Pedro's inability to provide reciprocal help to its Peruvian and Bolivian counterparts due to its lack of development.

With regard to relationships between San Pedro and communities in the TCO, with the exception of a few comments regarding some prejudice against indigenous peoples, households in San Pedro characterized their relationships with communities in the TCO as good. They reported that they traded visits to each other's communities for soccer tournaments and community celebrations. A number of households also commented on the development of personal relationships with residents of the TCO. However, one household reported difficulties caused by the language barrier, as many residents of Puerto Yaminahua speak only their indigenous language.

Households in San Miguel had a slightly different perspective on the quality of their relationship with other communities along the river. While they characterized their relationship with the other community in the TCO, Puerto Yaminahua, as strong and involving frequent communication, it was clear that their relationship with upstream communities, including San Pedro, Assis Brasil and Iñapari was weaker. While they occasionally traveled to San Pedro for community celebrations, this was not often the case with the other communities. Overall,

households reported that communication was limited with most communities other than their TCO neighbors.

Despite the existence of friendly relationships, it does not appear that agreements regarding aquatic and riparian resources are being created at the micro-regional level, nor are regular discussions taking place. In San Pedro, when asked whether agreements with other communities regarding the resource use or protection, 17 households stated that they did not exist, one household said that agreements did exist, and two households did not know whether such agreements existed. The single household that felt that agreements existed referred specifically to discussions that have occurred between residents of San Pedro and residents of the neighboring communities of Assis Brasil and Iñapari, Peru, but pointed out problems with enforcement of said agreements

> **Household #12**: I think there are [agreements]. There are agreements. For example, with Iñapari and Assis Brasil, we talk about how we shouldn't throw certain things into the river. It harms everyone. Perhaps a Peruvian could throw something, garbage, and hurt a Bolivian, but at the same time they hurt their own people because their people are circulating over here.
>
> **Interviewer**: Do they follow the agreements?
>
> **HH12***:* I don't think that they follow them. It's hard because there are people who do it secretly. For example, there are times that a chicken dies. And instead of digging a hole, they throw it into the river secretly at night. Nobody can control that.

Whether or not the agreement to which this household is referring has been formalized into an enforceable local regulation was not determined during this study. However, two additional households reported similar discussions with neighboring communities. One household stated that the residents of San Pedro are occasionally invited to participate in meetings held in Assis Brasil, but that their participation is limited to listening rather than making a substantive contribution. This informant also commented that he understood that discussions about environmental issues took place in Cobija, but that residents from San Pedro did not attend those

meetings or receive information from them. The second household also reported attending meetings on environmental matters in Assis Brasil, during which the participants were given tips for keeping the river clean

> Mostly we hear from Brazil that they come, invite us [to meetings] about ecology, maintaining clean rivers, not throwing garbage into the river. Through them, sometimes we do environmental preservation. Don't dirty the river, we don't contaminate, don't burn the forests.

Finally, in San Pedro, one household specifically referred to the tri-national organizing effort in the MAP region and reported that technical staff had visited the community to provide instruction on protecting the Acre River and its tributary streams

> That is what they are talking about with MAP. The three countries want to enter into an agreement, how we can rescue [the Acre River]. The river is drying up, it won't serve anyone. The technicians from MAP came and talked about the environment and how to protect it. They talked about some activities, like what do to with the garbage. But no one has done them. They talked specifically about how to protect the Rio Acre and the streams.

During the course of the interview, one informant explained why these types of agreements did not exist or were not necessary. He stated that because the community is not composed of fishermen, but rather agriculturalists, the need to control the use of aquatic resources like fish was unnecessary, and that national laws for riparian zone protection, albeit widely ignored, were already in existence. This statement reflects a common perception in San Pedro that because most of the community relies on farming for subsistence and does not depend heavily on rivers and streams for the provision of goods and services, the management of these natural resources is not a high priority. This attitude was clearly present in many of the responses to other questions during the interview.

Two important points emerge from the responses to this question. First, while the community of San Pedro is not in frequent communication with other communities in the area regarding natural resource issues, information is making its way to the community through the

work of NGOs and other partners in the MAP effort. Second, albeit at a limited level, communication does occur between communities, which indicates that at least some community members are becoming familiar with issues of resource management and protection in this region and that relationships between communities are being formed.

In San Miguel, responses to the question were quite similar. Every household reported that no inter-community agreements for resource management or protection existed. However, one household did recall having discussions about resource management with other indigenous communities in Brazil and Peru. Details of these discussions were not provided by the respondent, but my understanding was that these discussions occurred at international meetings of indigenous peoples

Household #4: We talk about everything.

Interviewer: What do you say about the protection of the water?

HH4: That you shouldn't throw garbage into the river. That you should protect it. In Assis Brasil and [San Pedro de] Bolpebra, they throw garbage. That's not good.

I: Do you also talk about deforestation?

HH4: Yes, that you shouldn't deforest because... we talk about everything.

I: Is everyone in agreement?

HH4: Yes.

Other than this single household, all other households in San Miguel did not recall having participated in discussions about resource management with other communities. However, as discussed above, some households recalled various workshops regarding natural resource management (including the protection of riparian areas) that had been held in the community, likely by the Fundación Jose Manuel Pando or researchers with the RIPUI project. Thus, as in

San Pedro, while information is not necessarily making its way between communities, at the very least it is arriving *to* the community.

The lack of coordination between communities in the watershed with regard to the protection of aquatic and riparian resource protection begs the question of whether the research communities were aware of or concerned about the impacts on them of the activities of upstream communities and, at the same time, aware of the impacts of their activities on downstream communities. In other words, were the households in these communities thinking about upstream-downstream connections and modifying their activities accordingly?

In San Pedro, when asked whether they felt that communities located upstream affected the water quality of the Acre River, every household responded affirmatively.[7] The most common concerns were sewage from Assis Brasil and Iñapari (18 households), and garbage (11 households) and dead animals (8 households) being disposed of in the river (11 households). Other concerns included the impacts of cattle from upstream ranches (n=3), waste from the hospital in Iñapari (n=2), agricultural activities that cause the river to fill with sediment (n=2), oil and gas pollution from outboard motors (n=2), grey water discharges from Assis Brasil (n=1), pollution from the cemetery in Iñapari (n=1), the town dump in Iñapari that occasionally floods (n=1), urine from livestock (n=1), and the poison *Barbasco* used in fishing (n=1).

Interestingly, when asked whether they felt that activities in San Pedro affected the quality of the water used by downstream communities, the responses were more varied. Eleven households responded that they did not feel that San Pedro affected the quality of waters flowing

[7] The phrasing of this and the following question was purposefully left vague in order to allow for responses that discussed activities that both improved and degraded water quality. However, while no household provided a response that indicated that water quality was being intentionally protected by activities in upstream communities, some responses indicated that the protection of downstream water quality was a purposeful decision made by some households.

downstream, while ten households responded that they did feel that San Pedro affected the water quality.

The most common explanations for San Pedro's lack of impact on water quality included the fact that sewage did not enter the river because the community has no sewer system (n=8) and that community members made a point of not disposing of their garbage in the river (n=4). Other, less frequent, explanations included the burying of dead animals rather than throwing them in the river (n=2), the fact that the community is located slightly inland and not directly on the banks of the river (n=1), and that the small scale agriculture conducted in the community does not cause a significant amount of erosion (n=1).

Ironically, in discussing San Pedro's negative impact on water quality, an equal number of households (n=4) stated that one of the major problems is that households *do* dispose of their garbage in the river. Other common explanations of impacts on water quality included washing clothes in the river and nearby streams (n=3), disposing of dead animals in the river (n=2), cattle ranching (n=1), and bathing domestic animals in the river (n=1). Obviously, due to the size of the community, these impacts are relatively minor. The fact that community members are aware of them, and of the impacts of upstream communities on them, however, indicates that they at least some people are thinking about the upstream-downstream connections in a way that is critical if any future cooperative management of the basin is to occur.

In San Miguel, responses were similar. When asked whether they thought that upstream communities affected the water quality in San Miguel, three households responded affirmatively, and two households responded that they did not know whether upstream communities affected their water quality. The most common concerns in San Miguel mirrored those in San Pedro.

These included the disposal of dead animals and garbage in the river (n=3, respectively) and sewage discharged by upstream communities (n=2).

When asked whether they felt that activities in San Miguel affected the quality of the water used by people who live downstream, only one household responded affirmatively. Interestingly, this was the only household in the community that shared a stream with another household. The head of household, therefore, was very aware that laundry soap made its way to the downstream household (though apparently this did not translate to concerns about human waste as this was the household discussed previously that had located its designated bathroom area on the bank of the stream). The households that did not feel that activities in San Miguel affected downstream water quality stated that they only use the streams for bathing, which does not negatively affect water quality (n=1), that toilets were not located near the streams (n=2), that they do not dispose of garbage or dead animals in the river or streams (n=1, respectively), and that they do not have nearby downstream neighbors to be concerned about (n=1). This last response was given by a household that was located both at a substantial distance inland from the river and from other households in the community, and therefore felt that the water from his stream had sufficient time to dilute before reaching the Acre River.

In summary, inter-community management systems have not been established along this stretch of the Acre River, nor are regular discussions about aquatic or riparian resource use and protection occurring. This does not mean, however, that no communication is taking place. At the very least, some discussions have occurred between communities and workshops have been held in both research communities regarding the protection of riparian areas. In addition, there appears to be an awareness of upstream-downstream connections in both communities. As might be expected, households in each community were more aware with how the activities of

upstream activities were affecting them than with the potential impacts of their activities on communities downstream. However, among at least a few households in each community, some conscious decision-making about controlling certain activities, such as appropriate locations for waste disposal, appeared to be in effect. This level of consciousness could be important to future management activities in the watershed.

CHAPTER 6
LOCAL PERCEPTIONS OF WATER QUALITY

As demonstrated in the previous section, households in San Pedro and San Miguel have not developed community-based management systems for governing aquatic and riparian resource use, nor have these types of management systems emerged at the micro-regional level. In both cases, however, informal discussions about the protection of these resources do occasionally take place, which could eventually result in a more coordinated resource management system. The potential for this type of collective management will be discussed in more detail in the final chapter of this document.

In Chapter 3, it was established that the research communities are not as dependent upon aquatic and riparian resources as one might expect, given their geographic location in a water-rich area. This fact could partially explain the lack of a need for formalized management systems to ensure that these resources are not overexploited. However, the lack of systems for resource protection could also have to do with the fact that, particularly with regard to riparian areas, households in these communities do not see local activities as having a major impact on water quality, nor do activities conducted in riparian areas by upstream communities seem to be of major concern. In other words, the ways in which riparian land is used are not strongly linked to concerns about water quality, thus reducing the perceived need for managing these areas. Rather, concerns about water quality focus on waste generated by the increasing urbanization of the region, which creates water quality problems that are more difficult to manage through changes in activities at the individual or household level. The following section will highlight the most common concerns about water quality as reported during the household interviews.

San Pedro

Public opinion in San Pedro is that the water quality in the Acre River is below acceptable standards. When asked whether they thought the Acre River was clean or dirty, every household unequivocally stated that they felt it was dirty, which explains why most households do not use it as a primary source of water for domestic use. Explanations for the poor water quality varied (Figure 6-1), but all were related to activities conducted by upstream communities. The pollution source of most concern was raw sewage (n=19), particularly that originating in urbanized areas like Assis Brasil and Iñapari. A number of households mentioned pipes that discharge directly into the river. The use of the river as a place to dispose of garbage and dead domestic animals (n=12 and n=11, respectively) by upstream communities was also a concern, perhaps because these forms of pollution are highly visible as they are carried downstream.

Other sources of pollution seemed to be of less concern, accounting for only a small proportion of the total responses. These included oil and gas discharges from outboard boat motors (n=3); dead wild animals (n=2); and waste from the hospital, cemetery, and landfill in Iñapari (n=2, n=1, and n=1, respectively). As illustrated in Figure 6-1, very few households reported concerns that linked land use with water quality. Two households reported that the river is dirtied by erosion due to riparian agriculture, and one household reported that agriculture has a negative effect on water quality but did not specify what that effect was. However, an equal number of households (n=2) reported problems with turbidity and erosion that were not attributed to human land use, but rather to rain and naturally loose soils. Two additional households reported concerns with pollution from domestic activities (laundry, bathing, etc.) by upstream communities. In general, then, pollution that could be sourced to urban areas was of more concern than pollution from smaller communities or from the use of riparian areas for agricultural or ranching purposes.

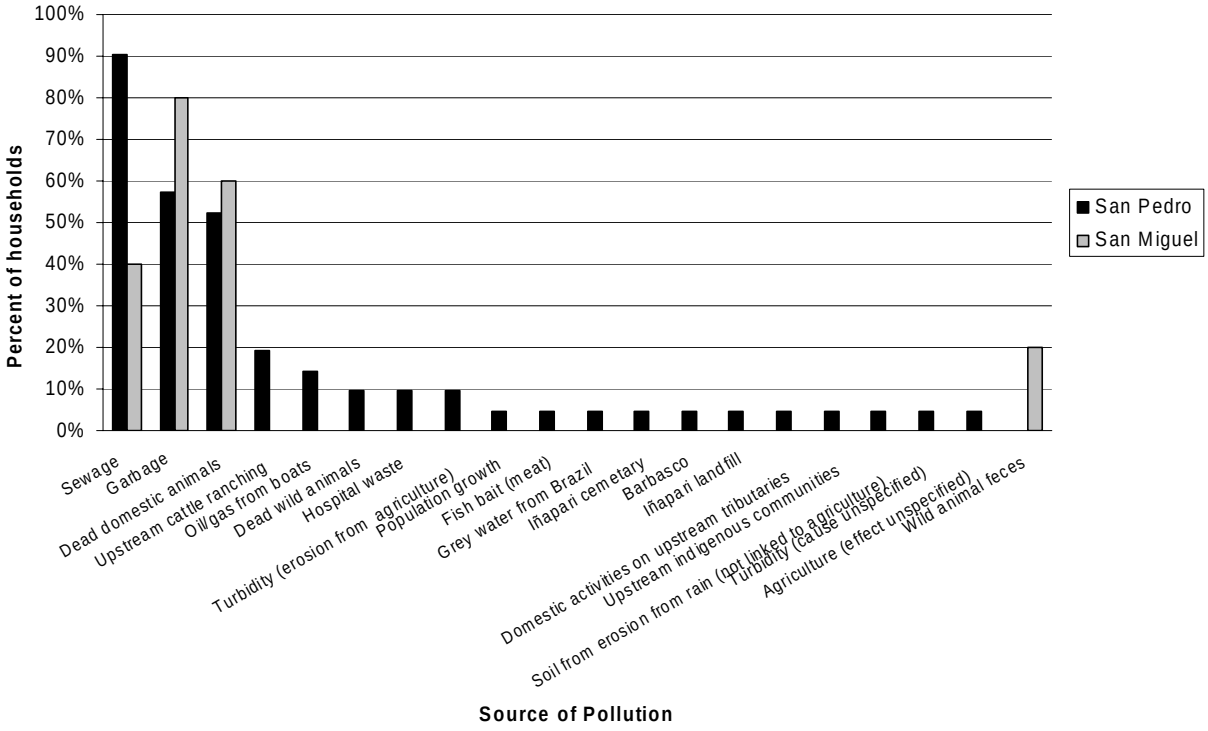

Figure 6-1. Perceived sources of water pollution in San Pedro and San Miguel.

Interestingly, when discussing the water quality in streams and springs near the community, most households felt that water from these sources was relatively clean. With regard to streams, 14 households felt that they were clean; two households felt that they were cleaner than the river but not perfect; and two households did not know whether the streams were clean or did not answer the question. Only three households felt that the streams were dirty. This perception of cleanliness seemed to originate from the fact that there are few people living along the banks of smaller streams, therefore problems with garbage, sewage, and agriculture do not exist, and because the distance from source to mouth is generally much shorter in streams than in rivers, which reduces the opportunity for pollution. One household, however, pointed out that streams in the area are currently threatened with contamination from cattle ranching and agriculture. The few households that felt that local streams were contaminated attributed this problem to the disposal of garbage in the streams by people within the community, free-roaming

domestic animals like pigs, organic material from the forest, and to the fact that they did not know what activities were taking place upstream.

Public opinion was slightly more split about water quality in the springs that the community uses for domestic purposes. Ten households felt that the springs were clean, while nine households felt that they were dirty and one household felt that some springs were clean (such as the one that the community uses for the potable water supply), while others were not as clean (such as the spring that some households use for laundry and hand-collected water). Explanations for poor water quality in the springs focused almost exclusively on natural contaminants such as leaves, insects and other animals.

While the prevailing opinion about the good water quality in the springs was that it was due to the fact that water was collected at the source and therefore did not have much opportunity to become contaminated, two households explained the good water quality by spontaneously referring to local agreements that prohibit deforestation around the most frequently used springs. One informant stated that the community preserves a buffer of 80 meters around the closest spring, which is used for laundry and hand-collected domestic water. The same informant claimed that a 100-meter buffer is maintained around a more distant spring, which supplies the community with its piped potable water. He stated that the community is in agreement about protecting those areas. The household that “owns” the land on which the distant spring is located was in agreement about the rule for protecting the area, though the informant reported a slightly narrower buffer zone of 50 meters

Interviewer: Is that a community rule, that you won't touch it?

Household #29: No, it's among us. It's not imposed by anyone because it doesn't befit us.

I: And if someone wanted to cut the trees . . .

> **HH29**: In that case, since I'm the one who works that land, I wouldn't do it, much less let anyone else touch it. If we deforest that, it would lose its natural state. There is a risk that the water would lessen and lessen and dry up. In the future, we could use a stream, but we would have water of perhaps lower quality.

Interestingly, when asked about local rules for resource protection (as discussed in the last section), only one household noted that this agreement existed, but characterized it as informal and discussed it in the context of the community putting a stop to the landower's desire to clear the area around the spring for agricultural purposes. These differing explanations call into question the extent to which this agreement is accepted by the community as a rule and the extent to which the rule is abided by. On the other hand, it does indicate that at least some community members consider the protection of areas around water sources to be necessary.

In addition to exploring perceptions of current water quality, the question of whether households felt that the water quality had changed since they arrived in the region, and whether they felt that it might change in the future also seemed relevant. This series of questions was intended to reveal whether the community was concerned enough about past changes and future threats to water quality to motivate them to participate in collective action to address these issues.

Sixteen households stated that they felt that water quality had changed since their arrival to the community, four households stated that water quality had not changed, and one did not know due to the lack of scientific testing. Of the 16 households that felt that water quality had changed, only two felt that it had improved, stating that there is now less garbage in the river due to growing awareness of the negative impacts of this type of contamination. With the exception of one respondent who chose to discuss changes in water quantity as opposed to water quality, the remaining households felt that water quality had deteriorated. The principle cause for concern appears to be population growth, as it is closely associated with greater amounts of sewage,

garbage and other contaminants. Additional, albeit less frequently mentioned, causes of deterioration in water quality include increasing numbers of cars being washed in the river, agriculture, ranching, and a general growth in the accessibility of the region via the Transoceanic Highway. As mentioned above, some households also expressed concern about changes in water quantity, stating that the river channel is becoming noticeably wider and shallower each year. This change is affecting the use of the river for transportation.

As for the future, 12 households felt that water quality would continue to change, three households did not think it would change, five households felt that it might change, and one household did not know. Of those who thought that water quality would change, 11 households felt that it would worsen if the population of the area continued to grow and if there was not a method for increasing the awareness of the impacts of water contamination, particularly on the parts of the more developed towns of Assis Brasil and Iñapari. Additionally, concerns about water quantity were brought up by a few of households. On the other hand, one household felt that water quality could improve if an appropriate project was put into place. This was also the general consensus for those households who were undecided. While they felt that water quality would continue to worsen with population growth, the implementation of appropriate development projects, environmental education, and stronger laws regarding water pollution could counteract some of the current problems.

Finally, because people tend to react most strongly when their personal welfare is threatened, informants were asked about health problems that they have experienced as a result of water contamination. Seventeen households stated that at least one member of the household had heath problems associated with water consumption or contact. Four households did not report problems. The most common ailments reported were *mancha blanca* (n=8), a skin

condition that results in discolored patches of skin (Figure 6-2) and skin fungi (n=6) (Figure 6-3). Other reported problems included skin rashes (n=4), urinary tract infections (n=3), diarrhea (n=2), typhoid fever (n=1), stomach infections (n=1), and intestinal worms (n=1).

Figure 6-2. *Mancha blanca*, a common skin problem attributed to contaminated river water in San Pedro.

Figure 6-3. Fungus, a common skin problem attributed to contaminated river water in San Pedro.

San Miguel

As in San Pedro, public opinion in San Miguel is that the Acre River is contaminated. When asked whether they thought the river was clean or dirty, all households stated that they felt it was dirty. Again, most households do not use the river as a primary source of domestic water, preferring to construct their houses next to smaller streams. Perceived sources of contamination were less varied than in San Pedro (see Figure 6-1), likely due to San Miguel's location

substantially downstream from Assis Brasil and Iñapari, which shielded them from observing many of the effects of urban development that were of concern further upstream in San Pedro. However, like in San Pedro, concerns about water contamination were not linked to the use of riparian areas. The most common sources of concern were those that are highly visible: garbage and dead animals (n=4 and n=3, respectively). Sewage from Assis Brasil in particular was of concern to two households.

With regard to local streams, all households felt that they were clean and, at the very least, were cleaner than the river. Three households stated that the only source of contamination was when animal died upstream, while two other households felt that the streams were clean because there were no people living upstream to contaminate them with garbage. In addition, one household stated that the streams were only dirty when it rained, but did not attribute the turbidity to human activities that create problems with erosion.

Opinion in San Miguel was split regarding whether water quality had changed since their arrival to the region. Three households stated that it had not changed, while two households felt that it had. However, in further exploring the responses of those two households, it became clear that they were referring to water quantity rather than water quality, stating that the river seems to be drying up.

As for the future, four households stated that they believed water quality would change. Interestingly, of these households, three thought that it could actually improve through public education, better regulations, and reducing deforestation. The fourth household, however, felt that the growing populations of Iñapari, Assis Brasil and San Pedro would create more pollution in the forms of garbage and sewage. The remaining household felt that water quality would not

change (meaning that it would not improve) unless a strong government existed in Assis Brasil that could prevent the pollution problem that is sure to occur as its population grows.

As in San Pedro, households in San Miguel were also asked about health problems that they associated with river water consumption or contact. Health problems appear to be less of an issue in San Miguel than they were in San Pedro. Only two households (out of five) reported health issues. One household reported skin rashes and the other reported fever, diarrhea, and headaches when the children played frequently in the river.

Conclusion

Ultimately, in both communities, there appears to be consensus that the Acre River is polluted to the extent that people often avoid using it for daily tasks like water collection, bathing, and laundry. Fortunately, each community has an alternate water supply, which most households are more confident is clean or, at the very least, cleaner than the river. Due to this perception, very few households reported treating drinking water prior to consumption. Households in San Pedro that reported treating their drinking water preferred to boil it, while households in San Miguel preferred the use of chlorine.

Concerns about contamination are generally tied to problems with urban development in the region, rather than to uses of riparian land (such as agriculture or cattle ranching). Most households feel that problems with water pollution will continue to increase, particularly as population centers grow due to better road access. Very few households discussed the existence of local environmental education programs that could serve to counteract the effects of this population growth. Health problems associated with water pollution do not seem to be serious in the sense that people feel their lives are threatened, but they are common enough to warrant further investigation and a focus on providing potable water systems.

CHAPTER 7
CONCLUSIONS

Introduction

At its base, my research is rooted in three fundamental questions. First, how do two culturally distinct Bolivian communities use aquatic and riparian resources? Second, do local strategies for protecting these resources exist and, if they do, are they based in a common property management system? Finally, if collective management is not currently taking place, do features favorable to collective action to protect these resources exist, namely dependence on the resource and group solidarity among residents of the watershed?

Given the speed with which development is occurring in Acre, Brazil and Madre de Dios, Peru due to the paving of the Transoceanic Highway, these questions are extremely relevant to the communities living on the banks of the Acre River, as water quality is likely to be affected. Despite the rapid development of this region, however, it must be recognized that each department that composes this tri-national area is located on the periphery of its respective country, far from centers of commerce, wealth, and political power. McClain et al.'s (2001) discussion about the challenges faced when attempting to protect water quality in remote regions of the Amazon, discussed in the introduction to this thesis, are therefore highly applicable to the MAP region.

In the absence of the money and political will to provide water treatment infrastructure and technical support, it is likely that for the foreseeable future, water quality protection will be left in the hands of local users. Restricting the use of water bodies for waste disposal and the protection of riparian areas are potential strategies for achieving this goal. The management structure under which protection could occur, ranging from ad hoc household strategies to micro-regional cooperative management, will depend on the factors discussed above. How dependent

upon river resources are these communities, and do they conceptualize river resources in the same ways? What is the relationship of this dependence, or lack thereof, to the potential for conserving and managing these resources? Do local (or larger scale) management systems for the protection of aquatic and riparian resources exist and, if so, what form have they taken? Are resource stocks clearly defined and have formal rules regarding the use of these resources been created and enforced? Are some potential users excluded based on these rules? Or is the exploitation of aquatic and riparian resources uncontrolled, as it would be in an open-access system? Is there a sense of urgency with regard to protecting these resources for future use? Are concerns about water quality sufficiently strong to motivate watershed residents to take action? Does enough group solidarity exist, either within the research communities or among communities in the watershed, to facilitate collective action to manage these resources sustainably?

The results of the research that attempted to answer these questions were presented in Chapters 4-6 of this thesis. Chapter 4 focused on the use of aquatic resources (with a focus on fishing practices and fish consumption), the conceptualization of aquatic and riparian resources, and the use and protection of riparian areas. Chapter 5 investigated the existence of governance structures under which the use of these resources occurs both within the research communities and among communities in the area. Finally, Chapter 6 discussed current perceptions of water quality, perceived sources of pollution, and health problems that households have experienced as a result of contact or ingestion of contaminated river water. This discussion will attempt to weave together the results presented in these chapters in order to address each research objective.

Revisiting the Research Objectives

Use of River Resources

As can be expected due to their location on the banks of the Acre River, the communities of San Pedro and San Miguel both use river resources to a certain extent. These uses include fishing, transportation, water for limited domestic purposes such as bathing and laundry, and the use of riparian areas for agriculture and the provision of trees and plants for household use. However, households in each of these communities also rely to a large extent on local streams and springs for drinking water, as these are considered to be cleaner and, in the case of San Miguel, are located closer to each house.

The extent to which these communities *depend* on river resources for daily survival, however, is considerably different. In San Pedro, fishing is considered to be a recreational activity. Most residents fish a few times per year at most and do so because they enjoy the variety in their diet. On average, households reported eating approximately 41.5 kg of fish per year (including fish purchased from commercial fishermen), a quantity that constitutes only 9% of the major sources of animal protein consumed. In San Miguel, on the other hand, households report fishing much more frequently. According to a brief log of daily diets over an eight day period, fish constituted approximately 15% of their total animal protein intake (a total of only 2.5 kg for all three households surveyed, but it is important to note that this was an atypical week due to the arrival of government-sponsored food as relief from flooding that had occurred earlier in the year). However, while the residents of San Miguel clearly fish more frequently and perhaps even consume more fish than residents of San Pedro, neither community relies on fish protein to the extent predicted by previous studies of rural communities in the Amazon. McClain (1999) reported that rural Amazonian communities have an annual per capital fish consumption of 101 kg, while Pierret and Dourojeanni (1967) found that fish constituted 62% of animal

protein consumed by people in rural areas of the Ucayali River basin in Peru. Fish consumption in my Bolivian research communities does not even begin to approach those figures.

With regard to the other uses of river resources, the picture is mixed. Most houses in San Pedro are constructed of planed timber with tin roofs, thus eliminating the need for collecting cane and palms that grow in riparian areas. While fruit, such as the palm fruit *asaí*, is occasionally harvested from trees growing in riparian areas, it does not constitute a critical element of households' daily diet. There is also little to no familiarity with aquatic plants. Though the use of these resources is minimal, however, the results of the freelisting exercise indicate that individuals, particularly men, have some knowledge of animals, trees, fruits, and other plants that exist in riparian areas. On the other hand, the value placed on riparian areas does not appear to include the use of these products. No households listed the provision of plants for consumption when asked about the importance of riparian areas, even though these plants (like *asaí*) are used on occasion. Additionally, households do not generally consume game species that populate riparian areas. Most households use the river as the primary location for bathing and laundry due to its proximity, though feelings about this use are mixed due to concerns about contamination. Finally, the river's usefulness as a means of transportation is limited by the fact that few households own canoes.

In San Miguel, both the freelists and interview questions about the perceived importance of riparian areas indicated that this community has more familiarity with these resources and tends to utilize them to a greater extent. Individual freelists of aquatic and riparian resources were longer on average, and the content coincided with the value placed on riparian areas. For example, tree and fruit species were frequently listed, and the provision of plants for household consumption was the most valued aspect of riparian areas. Furthermore, houses are constructed

out of cane and thatch, resources that households reported gathering in riparian areas. On the other hand, as in San Pedro, there was no reported use of aquatic plants, and the transportation value of the river is limited, as no households own travel-quality canoes. Unlike in San Pedro, households rarely use the river for bathing and laundry, preferring instead to use smaller streams near their homes. While this is in part due to concerns about water quality in the Acre, it also likely has to do with the more convenient location of the streams.

Riparian areas are used in both communities for agricultural purposes, with a majority of fields located within 100 meters of a surface water body. However, given the fact that many of these water bodies are small streams, the extent to which the surrounding area can be considered to be part of the riparian zone is questionable. In general, proximity to a riparian area does not appear to be a determining factor in the choice of crop location. That decision seemed to be more influenced by soil type than by perceived soil fertility.

It was originally hypothesized that the indigenous community of San Miguel would utilize river resources to a greater extent than the colonist community. While this hypothesis appears to have been supported, the larger picture indicates that the dependence on river resources for survival is not as strong in either community as was expected. In general, households rely on alternative sources of drinking water and, in San Miguel, for domestic supply; depend upon protein sources other than fish to a large extent, do not make extensive use of forest products found in riparian areas, and do not use the river for transportation to a large extent. This is not to say the Acre River is not important to these communities. The river clearly serves as a part, albeit a small one, of livelihood systems in each research community.

Existing River Resource or Water Quality Protection Strategies

As stated above, most agricultural fields in San Pedro and San Miguel are located within 100 meters of a surface water body. This situation creates an ideal setting for analyzing the maintenance of vegetation in riparian areas as a water quality protection strategy.

Households in both communities reported maintaining riparian buffers when creating agricultural fields. A larger percentage of households in San Miguel reported maintaining vegetation in these areas during the semi-structured interviews (100%, as opposed to 50% in San Pedro), but participatory mapping revealed that 61% of households in San Pedro actually preserved a buffer on at least one of their fields, while 80% of households in San Miguel did so. According to the participatory maps, this practice resulted in the maintenance of a riparian buffer on 68% of fields in San Pedro and on 91% of fields in San Miguel. Interestingly, according to the participatory maps, the average width of riparian buffers was considerably narrower in San Miguel than it was in San Pedro, a finding that mirrors the pattern encountered by McClain and Cossío (2003) in their study of water use among indigenous and colonist communities in the Peruvian Amazon. The reason for this difference was not determined by either McClain and Cossío's study or by this one.

It is clear that the preservation of riparian buffer zones between agricultural fields and surface water bodies is a strategic decision on the part of the households who do so. Households in both communities had reasoned explanations for this practice, including providing shade in order to maintain water quantity and a cool temperature, preventing erosion, preserving soil moisture, preventing crop loss from flooding, and capturing ash from burned fields. On the other hand, in San Pedro, the cultural norm of "cleaning" an area by removing all vegetation from it for aesthetic reasons also exists, and is one of the reasons households choose to not leave riparian buffers. Another reason reported for not maintaining riparian buffers is to provide access to

drinking water for cattle. This results in an inverse relationship between field size and the width of riparian buffers in San Pedro. This issue could be an interesting hook for an education program regarding alternative pasture systems because it is likely to be increasingly relevant in the future as many households in San Pedro eventually hope to own cattle.

In general, the importance of riparian areas is recognized by households in both communities, albeit for different reasons. In San Pedro, the ecological function of riparian areas was highly valued, while in San Miguel, households placed more value on the forest products located in these areas that could be used in the home for consumption and construction. Regardless of the reason, the point remains that riparian areas are understood to be critical parts of the river ecosystem, which bodes well for their long-term protection. And, as McClain and Cossío (2003) argue, this value system is an excellent place to begin in terms of reinforcing good practices, implementing education programs about the ecosystem services provided by these areas, and strengthening the institutional framework for maintaining these practices.

Although important, the protection of riparian areas is only one strategy for the maintenance of good water quality in tropical areas. Another strategy is the prevention of direct forms of pollution, such as sewage and solid waste. In this aspect, households in San Pedro and San Miguel are extremely conscientious. Neither community disposes of waste either on the river banks or in the river itself, nor is sewage channeled to the river. However, while this may be the case in the research communities, it is probably not the case for the communities upstream based on accounts given by households in the San Pedro and San Miguel. The contamination that reportedly flows downstream from Iñapari and Assis Brasil is a source of considerable concern to the research communities.

Ultimately, the protection of natural resources at the household level seems to be occurring to some degree in both communities. While it is not a perfect system in its implementation, there is a consciousness of the importance of maintaining good water quality and actions that can be taken at the local level that make this possible. As will be discussed below, however, the expansion of these principles to the community or micro-regional level in the form of a common property management system has yet to occur.

Local Opinions of Water Quality

As noted above, the general perception in both San Pedro and San Miguel is that water quality in Acre River is poor. While this perception does not prevent people from using it entirely, especially in San Pedro, it does limit the amount of water contact that people are willing to have. Fortunately, both communities have access to alternative sources of drinking water in the form of springs and streams, which are perceived to be clean, or at least cleaner than the river.

Major sources of pollution are thought to be tied to the relatively urban centers of Iñapari and Assis Brasil. Garbage and sewage rank high on the list of concerns, as does the disposal of dead animals in the river. It is conceivable that these are the issues of most concern because they are the most visible. Only a few households in San Pedro, and none in San Miguel, identified sediment loads as a source of pollution. Of these, only two linked it to agricultural practices in riparian areas that have led to increased deforestation (and none identified other forms of agricultural pollution, such as fertilizers and pesticides, as a source of concern). This is an important point, as it could have implications for future approaches to watershed management. If households do not perceive erosion to be a major issue, they could be less likely to believe in the effectiveness of a management plan that focuses on best management practices like preserving

vegetation in riparian areas. To be effective, a management plan may need to address a wider spectrum of contamination sources.

With regard to the direct effects of poor water quality, most households in San Pedro reported that at least one family member had experienced health problems as a result of contact or ingestion of river water. Households in San Miguel had experienced fewer health problems, likely due their downstream location, which allows for the dilution of contamination from Assis Brasil and Iñapari. However, despite reports of health problems, only a small number of households reported treating drinking water before consumption. The most common technique in San Pedro was boiling, and in San Miguel was chlorine. Ultimately, while health problems associated with contaminated water do not appear to be life threatening, they are a source of concern and should be addressed in any future management efforts in the watershed.

Governance of Riparian and Aquatic Resources

As stated above, despite the existence of household-level strategies for protecting riparian areas and conscious decisions to minimize the direct contamination of water bodies with garbage and sewage, these strategies have not coalesced into a formalized management plan at either the community or the regional scale. The research presented in this thesis indicates that both San Pedro and San Miguel lack all four features that define a functional common property resource regime - an ownership arrangement with management rules, clearly defined physical boundaries, sanctions to ensure compliance, and conflict-resolution mechanisms (Ostrom 1990).

In addition to the lack of a formal management system, informal agreements about resource management are also minimal. The only informal agreement that exists in either community, as revealed during the household interviews, is one created by the residents of San Pedro that restricts deforestation around the community's drinking water springs. Whether this agreement is common knowledge is questionable, however, as only two households commented

on it. Informal discussions about resource management occasionally occur in both communities (more frequently in San Miguel) but generally take place between individuals rather than in a group setting. Some of these discussions seem to have been motivated by occasional trainings given by staff from the Fundación Jose Manuel Pando and by community meetings organized by the Field Museum's RIPUI project.

One barrier to the creation of cooperative resource management systems within the community of San Pedro, as expressed by a number of households, is the inability to control access to those resources by individuals from Brazil and Peru. Residents of San Pedro question the point of attempting to manage the community's use of natural resources when they are unable to ensure that this management will have the intended effect due to forces beyond their control. While this is an obvious source of frustration for the community, it also speaks to the need for dialogue between residents of the countries in this tri-national area. As indicated by the results of my research, no attempts at coordinating inter-community resource managements systems have occurred, despite a basic level of communication about other issues among communities along this stretch of the river and an awareness of upstream-downstream connections as they relate to water contamination.

It was originally hypothesized that the river and riparian areas would be conceptualized as open-access resources, rather than as common-pool resources. This hypothesis was supported by my research results, but perhaps for slightly different reasons than originally predicted. While the size of the watershed and the diversity of communities within it may be factors that limit the potential for cooperative resource management (this idea will be discussed again below), an equally important factor that emerged from my research was the lack of dependence upon aquatic and riparian resources for daily survival. Given such a minimal level of dependence,

there is little urgency to manage these resources in a cooperative way. Furthermore, the sources of pollution that are of most concern to the communities are extremely difficult to address through the kinds of local-level efforts that are most viable in small communities. Raw sewage, large quantities of garbage, and hospital waste, just to name a few, are issues that perhaps can only be addressed through large financial investments in infrastructure, which are unlikely to occur in this region. From a more optimistic angle, however, perhaps the fact that people are concerned with water quality and tend to have good relationships with other communities along the river could mean that some strategy for addressing these concerns might eventually be devised.

Social Organization and the Potential for Future Collective Action

This research objective is perhaps the most difficult to address because it calls for the researcher's impressions of each community. The following discussion should therefore be read critically.

Overall, it seems that the hypothesis that social organization within the community of San Miguel would be more likely to support future common property resource management than that in San Pedro is correct for three reasons. First, as stated previously, every household in San Miguel is related to every other household by way of blood ties. This alone creates a congenial atmosphere and residents claim that conflicts in the community are rare. As far as I could determine from my short stay in the community, this is an accurate statement. This lack of conflict does not apply to San Pedro. Only six of the households in San Pedro are related; the rest are not. More importantly, the fact that the households that are related include the mayor and his family creates a tremendous amount of tension in the community, as other community members feel that they mayor's family benefits disproportionately from opportunities provided by outside actors, such as the government and NGOs.

Second, the level of socioeconomic stratification in San Miguel is much less severe than in San Pedro. While differences in socioeconomic status are somewhat evident – some homes have more material goods than others, some families have more children to support than others – they are much more difficult to quantify than in San Pedro, where it is easier to determine the wealth of each household based on consumer goods and the appearance of the home.

Finally, while cooperative work for the benefit of the community occurs more frequently in San Pedro than in San Miguel, it is almost always a source of conflict. There exists within the community a general feeling that community work is difficult to organize because people will not arrive on time, or at all, when the time to work comes. This distrust of fellow community members is an integral part of the social milieu in San Pedro and could have implications for attempts at some form of organized resource management. In San Miguel, on the other hand, cooperative work for the advancement of the community rarely occurs, but households also seem to be willing to watch out for each other to a greater extent. The sharing of hunting catches, fish, and agricultural harvests is a common occurrence.

In the end, San Miguel is a socially and ethnically homogenous community that, if motivated to do so, could likely establish and abide by communal rules. It is also likely the community will remain so in the future, as the pattern of expansion thus far seems to be based on kin relations. San Pedro's population is more diverse, and conflicts based on socioeconomic status, access to land, and political corruption are relatively common. The implications for cooperative resource management are clear. In situations in which distrust exists and in which people cannot depend on each other to work for the benefit of everyone involved, cooperative resource management will be challenging.

If an attempt at collective resource management were to occur, however, it is likely that the community council (the *Organización Territorial de Base* or OTB) in San Pedro could provide the institutional structure for establishing resource management rules or resolving conflicts over resource use. It is a relatively strong organization within the community, as indicated by the good attendance at its meetings and the level of respect that its officers generate within the community. In San Miguel, on the other hand, the OTB is not an active organization. This leaves some question, therefore, about whether resource management decisions or conflict resolution could be accomplished through this organization. It is likely that a different institutional structure would be necessary in San Miguel.

With regard to the potential for collective action at the regional level, it seems unlikely that this will spontaneously occur. While relationships between communities along this stretch of the Acre River were characterized as good, they are also somewhat superficial. Outside of the occasional meeting to discuss natural resource issues (at a basic level) and health and education campaigns, attendance at community celebrations, and participation in soccer tournaments, there seems to be very little cooperation between the community of San Pedro and its Peruvian and Brazilian counterparts. This low level of contact applies to the communities within the TCO as well. San Miguel and Puerto Yaminahua are on friendly terms, participate in the indigenous center's (CIPOAP) activities together, and attend each other's celebrations, but do not seem to have organized beyond that. The situation is even more extreme between the communities at the tri-national border and communities in the TCO. While residents of San Pedro characterized their relationship with the communities in the TCO as good, particularly on an individual basis, residents of San Miguel did not feel that they had much communication with resident of San Pedro or with the other border communities. The lack of communication between these groups

likely has to do with two factors. The first is simply geographic. The communities are located far enough away from each other to restrict frequent contact. The second is cultural. Not only are the residents of the TCO indigenous, and thus have a different lifestyle from the colonist communities, but they also do not speak Spanish, which limits the amount and quality of communication that can occur. Ultimately, there does not seem to be a shared identity among these groups as residents of the same watershed.

The freelists and resulting non-metric multidimensional scales also indicate that there is not a great deal of consensus about the resources that constitute the domain of river resources. Consensus was much stronger within the research communities than between them. While this finding does not in and of itself negate the possibility of collective resource management, it does reflect a fundamental social heterogeneity - a different way of looking at the world - that should be taken into consideration when evaluating the potential for cooperative resource management or during the design of a watershed management plan.

Ultimately, however, the largest barrier to collective action at either the community or the watershed scale seems to be the lack of motivation to participate in it. Without a high level of dependence on aquatic and riparian resources to spark concern about the unsustainable use of these resources (if that is actually the case), there is little sense of urgency to engage in the time and labor intensive process of collective action.

Regardless of these barriers to collective action, it is a certainty that the tri-national portion of the MAP region will continue to develop as the Transoceanic Highway attracts new settlers. This development may have implications for the potential for collective watershed management. At the community level, it is my opinion that development will discourage spontaneous collective action in San Pedro and San Miguel. The greatest concerns of these communities with

regard to water quality have to do with activities far beyond their control. They are dealing with water quality problems that are essentially urban in origin, rather than those that have to do with the land use and management. This creates a situation in which the communities lack the power to effect notable change. At the regional level, however, the picture may be brighter. As the tri-national area urbanizes, water quality will likely become an increasingly important issue. This may stimulate discussions between communities in the watershed. Resolving large scale water quality problems requires large scale action.

Final Thoughts

By way of concluding, I would like to address my final hypothesis which was that the more reliant people are upon river resources for their livelihoods (i.e., the larger the percentage of subsistence products acquired from the immediate area), the greater will be their concern and willingness to participate in cooperative watershed management. In the end, this hypothesis was neither proved or disproved by my research, but does deserve some comment. Without exception, all households interviewed expressed a willingness to participate in and abide by the rules of a watershed management plan created with the input of the communities. For reasons discussed above, including a lack of dependence upon aquatic and riparian resources, a sense of dependence on outside actors for the creation and implementation of environmental policies, and a lack of existing cooperative structures among the communities in the watershed, the likelihood that this kind of plan will emerge spontaneously is slim. However, the fact remains that concerns about water quality exist and addressing those concerns while simultaneously addressing the protection of riparian areas may be a way to achieve local commitment to large-scale watershed management. With increasing road access to the MAP region and the accompanying population growth, water quality will only continue to deteriorate. It is therefore critical that a coordinated effort at water quality protection be attempted.

APPENDIX A
INTERVIEW PROTOCOL

San Pedro

Part 1. Family History

1. When did you arrive in San Pedro?
2. Where did you come from?
3. Why did you want to move here? Why did you choose this place?
4. What is the story of your journey here?

Part 2. Household Structure

1. During the community census that I conducted, you told me that ___ people live in this household. Is that correct? Do you have children who don't live here? How many? Where do they live?
2. Do you have family members in other houses in this community? Which ones? How are you related?

Part 3. Socioeconomic Indicators

1. What is your level of education?
2. What is your job/profession?
3. From what source does the majority of your annual income come?
4. What is your annual (or monthly/weekly) income? From what sources?
5. Do you have electricity?
6. Do you have running water at your house?
7. What types of appliances and electronics do you own?
8. Do you own livestock (cattle, pigs, chickens, oxen, etc.)? How many of each? Are they for your own consumption or for selling?
9. Are you in debt to anyone/any organization?

Part 4. Livelihood Systems

1. Freelisting:
    a. Tell me all of the resources that there are in the Acre River, the streams, and in riparian areas. Please be as specific as possible.
    b. How are those resources used?
    c. Of all the resources that you listed, which do you personally use? How much of each do you use and for what purpose?
    d. Tell me about how you spend your day.
2. What food items do you purchase?
3. Do you own the land that this house is built on? How many hectares do you have in the urban area?
4. Do you own land in the *monte* (forest)? How many hectares do you have? How many hectares do you use for agricultural purposes?
5. Do you own or have access to land along the river or streams? If so, how many hectares?
6. When you farm or harvest timber, do you leave a fringe of trees along the river or stream? If so, how many meters wide?
7. Tell me about your crops.

    a. What do you grow? How far from town are your fields? Where do you grow each crop? How do you decide where to put your chacos? Which products do you sell?
    b. Do you irrigate? If so, how?
8. Do you fish? If yes:
    a. How often?
    b. How (net or hook and line)?
    c. What types of fish do you catch?
    d. How many fish do you catch each day/week/year?
    e. How much fish do you eat each day? How much of other kinds of meat do you eat each day?
    f. Do you own a boat?
9. How much time each day do you spend on or near the river/streams each day?
10. Where do you get your drinking water and water for cooking?
11. How much water do you use each day? For what?
12. Do you treat your water before consumption? How?

Part 5. Resource Governance

1. Is there a limit on the number of fish that you can catch or the quantity of other aquatic or riparian resources that you can collect?
2. Does anyone control access to the river and streams and their resources?
3. Do you have any agreements within the community regarding the use of river resources or the protection of water quality? Where do the agreements come from?
4. Do you have any agreements with other communities regarding the use of river resources or the protection of water quality? Where do the agreements come from?
5. Are there agreements about riparian areas? Where do they come from?
6. What happens if someone doesn't follow the rules?
7. Do you think that communities upstream of San Pedro affect the water quality here?
8. Do you think that San Pedro affects the water quality downstream from here?

Part 6. Intra- and Inter-Community Dynamics

1. If a stranger/outsider asks you where you live, what do you tell them?
2. What values are most important in this community?
3. What types of conflicts or problems exist in this community? How are conflicts resolved?
4. What is the most *important* organization in this community?
5. What is the most *effective* organization in this community?
6. How would you characterize the relationships between San Pedro and other communities along the Acre River?

Part 7. Water Quality and Resource Protection

1. Do you think the river water is clean or dirty? Why? What about the streams? Why? What about the springs? Why?
2. Has the quality of the water changed since you arrived in San Pedro? If so, how? If not, why not?
3. Do you expect the quality of the water to change in the future? Why or why not?
4. Have you or has anyone in your family experienced health problems that you think are due to water contamination?

5. Do you think riparian areas are important? If so, why? If not, why not?
6. What kinds of things do you do to protect the river and streams and their surrounding areas?
7. What do you do with your garbage?
8. Do you have a bathroom? Where does the human waste go?
9. Would you be willing to participate in a watershed management plan that called for:
    a. Maintaining 100 meters of tree cover and vegetation along the river bank and 20 meters along streams?
    b. Planting trees along the river bank or allowing natural regrowth?

San Miguel

Part 1. Family History

1. How long have you lived in San Miguel? Have you always lived where your house is now?
2. Where did you come from? Where were you born?
3. Why did you want to move here? Why did you choose this place?
4. Where are you parents from?
5. Do you speak Machineri?

Part 2. Household Structure

1. How many people live in this house?
2. What are their names and ages?
3. Do you have children who don't live here? What are their names and ages? Where do they live?
4. Do you have family members in other houses in this community? Which ones? How are you related?
5. Where do your parents and siblings live?

Part 3. Socioeconomic Indicators

1. What is your level of education? Do you know how to read?
2. What is your job/profession?
3. From what source does the majority of your annual income come?
4. How much do you earn (or spend) in a month?
5. Do you have a radio? Bicycle? Flashlight?
6. Do you own livestock (cattle, pigs, chickens, oxen, etc.)? How many of each? Are they for your own consumption or for selling?
7. Are you in debt to anyone/any organization?

Part 4. Livelihood Systems

1. Freelisting:
    a. Tell me all of the resources that there are in the Acre River, the streams, and in riparian areas. Please be as specific as possible.
    b. How are those resources used?
2. What food items do you purchase? Where do you buy them?

3. How many hectares of land do you use for agricultural purposes?
    a. What do you grow?
    b. Where do you grow each crop?
    c. How do you decide where to make your fields? Do you sell any of your products?
    d. Do you irrigate? If so, how?
4. Are your fields close to the river or streams? If so, how many meters border the water?
5. When you farm or harvest timber, do you leave a fringe of trees along the river or stream? If so, how many meters wide?
6. Do you fish? If yes:
    a. How many times per week?
    b. Do you use a net or a hook and line?
    c. What types of fish do you catch?
    d. How many fish do you catch each time you go?
    e. Can you estimate how many kilos of fish you eat each day/week?
7. What other types of meat do you eat? How much? How many times a week do you hunt?
8. How much time each day do you spend at your stream each day? At the river?
9. Where do you get your drinking water and water for cooking?
10. How much water do you use each day for cooking? For washing dishes?
11. Do you treat your water before consumption? How?

Part 5. Resource Governance

1. Is there a limit on the number of fish that you can catch or the quantity of other aquatic or riparian resources that you can collect?
2. Does anyone control access to the river and streams and their resources?
3. Do you have any agreements within the community regarding the use of river resources or the protection of water quality? Where do the agreements come from?
4. Are there agreements about riparian areas? Where do they come from?
5. What happens when someone doesn't follow the rules? What do other community members do?
6. Do you have any agreements with other communities or people living along the banks of the river regarding the use of river resources or the protection of riparian areas?
7. Do you think that communities upstream of San Miguel affect the water quality here?
8. Do you think that the people here in San Miguel do things that affect the water quality downstream from here?

Part 6. Intra- and Inter-Community Dynamics

1. Describe where San Miguel is located.
2. Do you feel that San Miguel is a community that works together to improve, or is it simply a group of relatives that live more separate lives?
3. What values are most important in this community? How is it a Machineri community?
4. Are there problems or conflicts in San Miguel? How are conflicts resolved?
5. What kinds of organizations exist here? What is the most important organization in this community?
6. How are the relationships between San Miguel and the neighboring communities?

Part 7. Water Quality and Resource Protection

1. Do you think the river water is clean or dirty? Why? What about the streams? Why?
2. Has the quality of the water changed since you arrived in San Pedro? If so, how? If not, why not?
3. Do you expect the quality of the water to change in the future? Why or why not?
4. Have you or has anyone in your family experienced health problems that you think are due to water contamination?
5. Do you think riparian areas are important? If so, why? If not, why not?
6. What kinds of things do you do to protect the river and streams and their surrounding areas?
7. What do you do with your garbage?
8. Do you have a bathroom? Where is it located? Where does the human waste go?
9. Would you be willing to participate in a watershed management plan that called for:
    a. Maintaining 100 meters of tree cover and vegetation along the river bank and 20 meters along streams?
    b. Planting trees along the river bank or allowing natural regrowth?

APPENDIX B
PARTICIPATORY MAPS

Figure B-1. Participatory map of San Pedro.

Figure B-2. Participatory map of San Miguel.

LIST OF REFERENCES

Acheson, James M.
1987 The Lobster Fiefs Revisited: Economic and Ecological Effects of Territoriality in Maine Lobster Fishing. *In* The Question of the Commons: The Culture and Ecology of Communal Resources. B. McCay and J.M. Acheson, eds. Pp. 37-65. Tucson: The University of Arizona Press.

Adger, W. Neil and Luttrell, Cecilia
2000 Property Rights and the Utilisation of Wetlands. Ecological Economics 35:75-89.

Alvarez, Nora L., and Lisa Naughton-Treves
2003 Linking National Agrarian Policy to Deforestation in the Peruvian Amazon: A Case Study of Tambopata, 1986-1997. Ambio 32(4):269-274.

Ankersen, Thomas T. and Thomas Ruppert
2006 Tierra y Libertad: The Social Function Doctrine and Land Reform in Latin America. Tulane Environmental Law Journal 19:69-120.

Bardhan, Pranab and Jeff Dayton-Johnson
2002 Unequal Irrigators: Heterogeneity and Commons Management in Large-Scale Multivariate Research. *In* The Drama of the Commons. E. Ostrom, T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, and E.U. Weber, eds. Pp. 87-112. Washington, D.C.: National Academy Press.

Berkes, Fikret
1987 Common-Property Resource Management and Cree Indian Fisheris in Subarctic Canada. *In* The Question of the Commons: The Culture and Ecology of Communal Resources. B. McCay and J.M. Acheson, eds. Pp. 66-91. Tucson: The University of Arizona Press.

Bernard, H. Russell
2002 Research Methods in Anthropology: Qualitative and Quantitative Approaches. Walnut Creek, CA: Altamira Press.

Faminow, Merle D.
1997 Spatial economics of local demand for cattle products in Amazon development. Agriculture, Ecosystems and Environment 62:1-11.

Fearnside, P.M.
1993 Deforestation in Brazilian Amazonia: The Effect of Population and Land Tenure. Ambio 22(8):537-545.

Goulding, Michael, Ronaldo Barthem, and Efrem Ferreira.
2003 The Smithsonian Atlas of the Amazon. Washington, D.C.: Smithsonian Books.

Guest, Greg
2003 Fishing Behavior and Decision-Making in an Ecuadorian Community: A Scaled Approach. Human Ecology 31(4):611-644.

Gwynne, Robert N. and Cristobal Kay
1999 *Latin America Transformed: Changing Paradigms, Debates and Alternatives*. *In* Latin America Transformed: Globalization and Modernity. R. N. Gwynne and C. Kay, eds. Pp. 2-30. London: Arnold.

Hall, Anthony
1997 Sustaining Amazonia: Grassroots Action for Productive Conservation. Manchester, NY: Manchester University Press.

Hecht, Susanna and Alexander Cockburn
1990 The Fate of the Forest: Developers, Destroyers and Defenders of the Amazon. New York: HarperCollins Publishers.

Herbas, Monica Amparo
2000 Diagnóstico Socioeconómico del Nor Occidente de Pando TCO Yaminahua-Machineri, Reserva de Vida Silvestre Tahuamanu. Universidad Amazónica de Pando, Centro de Investigación y Preservación de la Amazonía.

Hunt, Robert C.
1992 Equality and Equity in Irrigation Communities. Paper presented at the Third Common Property Conference of the International Association for the Study of Common Property, Washington, D.C., September 17-20.

Kainer, Karen A., Marianne. Schmink, Arthur Cezar Pinheiro. Leite, and Mário Jorge da Silva Fadell
2003 Experiments in Forest-Based Development in Western Amazonia. Society and Natural Resources 16(10):869-886

Kay, Cristobal
1998 Latin America's Agrarian Reform: Lights and Shadows. Land Reform 2:8-31.

Kelly, William
1983 Concepts in the Anthropological Study of Irrigation. American Anthropologist 85:880-886.

Kolavalli, Shashi and Jeffrey D. Brewer
1999 Facilitating User Participation in Irrigation Management. Irrigation and Drainage Systems 13:249-273.

Lansing, J.S.
1991 Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali. Princeton: Princeton University Press.

Lifschitz, Suzana F.
1994 The State of Acre: A Discussion of Alternative Development Strategies. Master's Thesis. Dalhousie University, Nova Scotia.

Maher, Dennis
1979 Frontier Development Policy in Brazil: A Study of Amazonia. New York: Praeger Publishers.

Malingreau, Jean-Paul and Compton J. Tucker
1988 Large-Scale Deforestation in the Southeastern Amazon of Brazil. Ambio 17(1):49-55.

McClain, Michael E.
1999 Water Resources Management in the Amazon Basin: Issues, Challenges, and Opportunities. Proceedings of the International Conference "Great Rivers-99", UNESCO.

McClain, Michael E., Luis Miguel Aparicio, and Carlos A. Llerena
2001 Water Use and Protection in Rural Communities of the Peruvian Amazon Basin. Water International 26:400-410.

McClain, Michael E. and Rosa E. Cossío
2003 The Use of Riparian Environments in the Rural Peruvian Amazon. Environmental Conservation 30:242-248.

McGrath, David G., Fabio de Castro, Celia Futemma, Benedito Domingues de Amaral, and Juliana Calabria
1993 Fisheries and the Evolution of Resource Management on the Lower Amazon Floodplain. Human Ecology 21(2):167-195.

McKean, Margaret
2000 Common Property: What Is It, What Is It Good for, and What Makes It Work? *In* People and Forests: Communities, Institutions, and Governance. C.C. Gibson, M.A. McKean, and E. Ostrom, eds. Pp. 27-56. Cambridge, MA: The MIT Press.

Mitchell, William P. and David Guillet
1994 Irrigation at High Altitudes: The Social Organization of Water Control Systems in the Andes. Society for Latin American Anthropology Publication Series, 12. Washington, D.C.: American Anthropological Association.

Nemarundwe, Nontokozo and Michael Richards
2002 Participatory Methods for Exploring Livelihood Values Derived from Forests: Potential and Limitations. *In* Uncovering the Hidden Harvest: Valuation Methods for Woodland and Forest Resources. B.M. Campbell and M. K. Luckert, eds. Pp. 168-197. London: Earthscan Publications Ltd.

Olsson, Per and Carl Folke
2001 Local Ecological Knowledge and Institutional Dynamics for Ecosystem Management: A Study of Lake Racken Watershed, Sweden. Ecosystems 4(2):85-104.

Ostrom, Elinor
1990 Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press.

Ostrom, Elinor and R. Gardner
1993 Coping with Asymmetries in the Commons: Self-Governing Irrigation Systems Can Work. Journal of Economic Perspectives 7(4):93-112.

Pacheco, Pablo
2002 Deforestation and Forest Degradation in Lowland Bolivia. *In* Land Use and Deforestation in the Amazon. C. Wood and R. Porro, eds. Pp. 66-94. Gainesville: University of Florida Press.

Petrzelka, Peggy and Michael M. Bell
2000 Rationality and Solidarities: The Social Organization of Common Property Resources in the Imdrhas Valley of Morocco. Human Organization 59(3):343-352.

Pierret, P.V. and M.J. Dourojeanni
1967 Importancia de la Caza para Alimentiacion Humana en el Curso Inferior del Rio Ucayali, Peru. Revista Forestal del Peru 1:10.

Saravanan, V.S.
2002 Institutionalizing Community-Based Watershed Management in India: Elements of Institutional Sustainability. Water Science and Technology 45(11):113-124.

Steelman, Toddi A. and Joann Carmin
1998 Common Property, Collective Interests, and Community Opposition to Locally Unwanted Land Uses. Society & Natural Resources 11(5):485-505.

Stocks, Anthony
1987 Resource Management in an Amazon *Varzea* Lake Ecosystem: The Cocamilla Case. *In* The Question of the Commons: The Culture and Ecology of Communal Resources. B. McCay and J.M. Acheson, eds. Pp. 108-120. Tucson: The University of Arizona Press.

Taylor, Lawrence
1987 "The River Would Run Red With Blood": Community and Common Property in an Irish Fishing Settlement. *In* The Question of the Commons: The Culture and Ecology of Communal Resources. B. McCay and J.M. Acheson, eds. Pp. 290-310. Tucson: The University of Arizona Press.

Trawick, Paul
2001 The Moral Economy of Water: Equity and Antiquity in the Andean Commons. American Anthropologist 103(2):361-379.

Urioste, Miguel
2003 Abandoned agrarian reform: Valleys and high plains. La Paz: Fundación TIERRA.

U.S. Army Corps of Engineers
2004 Water Resources Assessment of Bolivia. U.S. Army Corps of Engineers. Washington, D.C. http://www.sam.usace.army.mil/en/wra/Bolivia/FINAL%20BOLIVIA%20WRA%20COMBINED%2013%20DEC%202004.pdf, accessed May 12, 2007.

White, T. Anderson and C. Ford Runge
1994 Common Property and Collective Action: Lessons from Cooperative Watershed Management in Haiti. Economic Development and Cultural Change 43(1):1-41.

BIOGRAPHICAL SKETCH

Gabriela Stocks earned a B.A. with honors in anthropology from the University of Chicago in 1998. After graduation, she worked for a non-profit organization dedicated to river conservation for four years. She began her graduate studies in anthropology at the University of Florida in 2003 as an Alumni Fellow. Her academic and professional interests focus on water resource development in the tropics, a subject area she will continue to study during her Ph.D. program in anthropology.